ROADS and STREETS

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A Certain Weakness in Engineering College Training

"Several years passed in a college of liberal arts constitute the worst possible training for youths who wish to become engineers. Insofar as possible, general culture subjects and the pure sciences should be taught from an engineering point of view by engineers." In taking this stand Dean Charles H. Snow, of the School of Engineering of New York University, voices an opinion that is becoming quite common among engineering educators. The other extreme was not only advocated but put into effect by President Butler of Columbia University, but the engineering attendance at Columbia fell off so rapidly that Columbia has again made it possible to take a four-year engineering course without a preliminary two-year arts course.

We agree with Dean Snow that engineers, as a rule, are more apt to be hindered than helped in their career by an arts course that consumes several years. There are exceptional cases, of course. If an arts course is so conducted as to train a student in self-education, that is in thorough searching for an analysis of information, it will not be time wasted. On the contrary, it may actually excel an engineering course that lacks that sort of training. But unfortunately there are few teachers, either in arts or in science, who give any real training in self-education.

Does it sound anomalous to speak of going to college to learn how to educate yourself? It should not sound so, and it would not were education less often regarded as a process of imparting knowledge than a process of inculcating habits. We have long been told that the prime aim of intellectual education is to teach men how to think, but haven't we lost sight of the fact that it is even more important to train men to do certain kinds of things almost automatically? For example, it is important to teach a man hygiene and how to interpret hygienic facts; but it is vastly more important to train him to be hygienic. Thus, most of us know enough of hygiene to know that we should exercise rather vigorously at least an hour or two daily; but how many of us have been so habituated to do it that we feel ill at ease if we miss a single day's exercise?

Much the same defect of education is seen in many graduate engineers when it comes to keeping up with engineering progress. They know they should, but they don't. They excuse themselves for not continuing their self-education by saying that they are too busy to study; when the real truth is that they never were trained sufficiently to be unhappy if they ceased their self-education.

"I begin," says Thomas Edison, "where others left off." That means that he makes a thorough study of what others have done in a given field before he undertakes to improve on their best accomplishment. How many engineers follow the Edison plan with his thoroughness? And if they usually are less thorough, is it not because they have not been trained to search carefully and systematically for information, as the first step in solving any problem?

Consider our engineering courses, and it will be seen that they contain relatively little training in searching for facts. Instead, nearly all the data are given to the student in his text books, and he is presumed to study only how to use the data. But in after life, his economic problems don't often come to him that way. The way an economic problem usually comes is as a problem with few accompanying data. The big job is to find the pertinent data. This means, if done properly, an exhaustive search for facts, an elimination of the unimportant facts, and thus on arriving at a point where one can say: I am now ready to begin where the others left off.

Our educators have imagined that if principles are taught, common sense will teach us to do the rest. But usually it doesn't work that way.

A scientific principle is nothing but a statement of some characteristic of a class of things. It is, then, nothing more than a fact itself, one, it is true, that is quite generally applicable, but still a fact. Why, then, this worship of a broadly applicable fact—a principle accompanied by what amounts to disdain of the vaster multitude of less broad facts? Why the careful teaching of principles, and the very careless training in fact gathering?

A highly successful executive had listened for some time to a dispute between two engineers over a solution of an economic problem. He interrupted them with: "What we lack, it seems to me, is facts. Either of you could solve the problem very quickly if you had enough facts. You are both long on theory and short on facts."

In another case, it was remarked that few errors are made because of faulty reasoning, but many are made because of insufficient data with which to reason. We are not sufficiently trained as fact harvesters. What good is a friction formula if the proper coefficient of friction is not known? Several dams have failed through lack of just that little bit of a fact. What good is the principle of capitalized annual expenses, if an improper interest rate is used in capitalizing? Yet many an engineer has used a bond interest rate of 5 per cent where he should have used an 8 per cent "fair return rate."

The smallest of facts is often more important than the broadest of principles. What aviator would not trade all his knowledge of principles of aeronautics for the knowledge that a flaw exists in one of the parts of his machine, which will mean death to him unless discovered?

Finally, the smallest fact carefully noted and its significance questioned, has led, many a time, to the entire revolution of a theory. Witness the little fact that the velocity of light is unaffected by the velocity of its source. Upon this was based Einstein's revolutionary theory, and a new formula for energy was deduced. The old classical formula, $k=\frac{1}{2}\ mv^2$, is found to be only a special case of a much more general formula. And a whole field of new knowledge unfolds.

There has been altogether too little training in fact-gathering and analysis in our schools and colleges. If an arts course involved a thorough grounding in the art of fact-gathering, it would be preferable to an engineering course in which such an art was not made habitual.

H. P. Gillette

Our Great Yet Inadequate Expenditures on Roads and Streets

About $1,120,000,000 will be spent this year in constructing and maintaining country roads, according to the Bureau of Public Roads. How much will be spent on city and town streets is unknown, for no similar statistics on this important branch of highway work have ever been gathered. If street work equals the combined expenditure for waterworks and sewers, another 300 million dollars should be added to the above. At any rate, the roads and streets of America are being built and maintained at an annual cost that approximates about one and a half billion dollars.

This is a mouth filling total, yet it is barely more than one and a half per cent of our gross annual income, a little less than $13 per capita, and a little more than $60 per motor vehicle. When the significance of this last figure sinks in, it will be seen that America has yet a long way to go before the annual expenditures on her highways may be regarded as being adequate.

Perhaps the greatest reason for hoping that highway improvement may some day catch up with the need for it is to be found in the gasoline tax. But there is a growing danger that politics will either curtail or divert some of that source of revenue. For example, the proposed 2-ct. tax on gasoline in New Jersey was made a political issue. The bill was finally passed over the governor's veto.

California politicians recently fell to wrangling over the gasoline tax and its allocation, and the result was an inadequate provision for highway improvement.

Pennsylvanians have been similarly quarreling. Philadelphia's streets are in rotten condition, and some of the gas-tax money is being demanded by certain Philadelphia newspapers. Perhaps they are right, but it all leads to a lot of political wrangling that delays progress.

Announcement of Our New Book Department

Ten years ago the publishers of this magazine sold its book stock and copyrights. Engineering and Contracting Publishing Co. now announces the repurchase of the copyrights of all the books written by Halbert P. Gillette and Richard T. Dana.

With this nucleus of nine books on construction subjects this company again enters the field of technical book publishing, and it will be glad to review the manuscript of any technical book with a view to its publication.

We publish three-paid circulation monthly magazines, each associated with a free-circulation supplementary magazine, making a total of six magazines whose total circulation is 70,000 copies monthly, half of which is paid. This is the largest circulation that any publisher offers in the construction field. Therefore, through the advertising pages of our magazines alone we can present the facts about any construction book to a very large number of prospective buyers.

We have on stencils the names of 100,000 men in the construction industry. Subscription circulars go regularly to all these men, and hereafter they will also receive circulars relating to our books.

The net paid circulation of our three-paid circulation magazines is in round numbers:

Engineering and Contracting	19,000
Roads and Streets	10,000
Water Works	7,000
Total	36,000

This is 36 per cent of the 100,000 names on our stencils. At the present rate of growth the net paid circulation of these three magazines will exceed 40,000 before the end of 1927. We mention this fact in this connection in order to make it clear to authors of prospective civil engineering and construction manuscripts that we are exceptionally equipped to reach prospective buyers of their books.

Those Roadside Markets

The roadside market, grown to great proportions with the development of the highway system, affords a valued outlet for farm products. Of real benefit to the farmer, it deserves encouragement.

Unfortunately, however, parasites have established themselves on the sturdy stem of this growing industry. City merchants, alive to the opportunity for ready profit, establish booths on rented land and haul quantities of food and other merchandise from the wholesale district of the city to that booth, tack on exaggerated price tags, and lay in wait for the unwary purchaser.

To discourage this undesirable element, says C. D. Buck, chief engineer of the Delaware State Highway Commission, a merchant's license should be obligatory, and that license posted conspicuously at the roadside booth. The fees could go into the road fund as a benefit to the public.

Taxing the Billboards

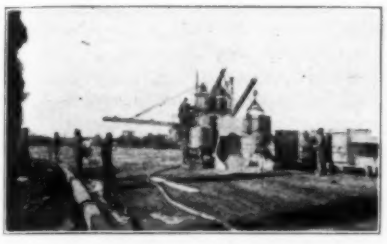
C. D. Buck, chief engineer of the Delaware State Highway Department, in recommending the taxation of roadside billboards for the benefit of the road fund, has opened an interesting topic for discussion. Billboards, widely used in this country for extolling the merits of a wide variety of merchandise, and many a hotel, or service, are usually situated upon private property and pay a rental for the use of the required land. So far, so good. Yet the sole charge against the advertiser is a form of rental paid by him to a party of lesser benefit. The party of greatest benefit to the advertiser is the public traveling over the road, for it is to that public the advertiser desires to sell his wares.

Should not the advertiser, then, pay the public for that opportunity? Such a payment, or rent, paid in the form of a tax to go into the road fund, would materially reimburse the public for having to gaze upon the often unsightly structures instead of the beauties of nature.

Then, too, the revenue would be of material aid to the public. In Delaware, for instance, where many such advertisements have been posted, it is estimated that an annual tax of 8 ct. a square foot levied upon all signs now situated within 200 ft. of the state highways would produce a revenue sufficient to maintain 45 miles of roads for a year.

Highway Methods Used on Chicago Street

Special subgrade conditions on the construction of the golf course and Simmon's Island Drive, Diversey Parkway, in Lincoln Park, Chicago, paved last fall, necessitated the use of methods that are ordinarily never used in the congested portion of a large city. In planning this job, which called for 38,000 sq. yd. of sheet asphalt top and concrete base on a new high speed thoroughfare a mile long and 45 ft. wide, the contractors had to figure on laying at least 1,000 sq. yd. of base and 2,000 sq. yd. of binder and top during each day of operation on each part of the work.



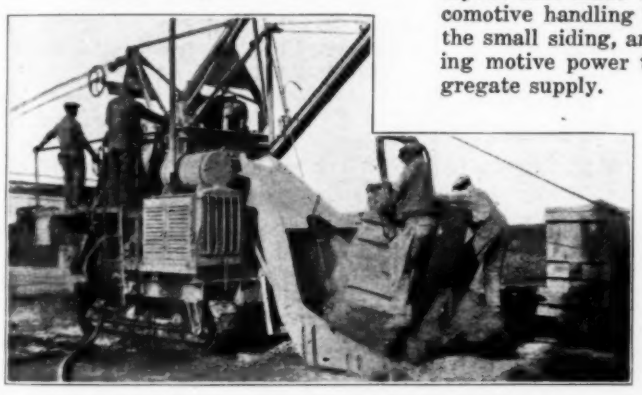
A Train at the Mixer, With Proportioned Batches Ready for Use

Since the use of trucks might prove troublesome on the soft subgrade, 2 Plymouth locomotives, 12 Lakewood cars, 24 batch boxes, and a quantity of narrow gage track were secured for handling the concrete materials. Trucks delivered the aggregate to the Butler batcher bin, into which the materials were loaded by a Byers crane. Cement was hauled to the job in trailers, and was unloaded directly into the batch boxes as needed. The batch boxes on the cars, which were made up into four trains of three cars each, received first the aggregates and then the cement, and delivered these materials to the 27-E Foote paver. The two locomotives each handled two trains, there being practically no idle time. The drawing on this page shows the unique track layout that made this possible, one locomotive handling trains to the left of the small siding, and the other furnishing motive power to and from the aggregate supply.

The asphalt equipment included a 500 ton per day stationary plant 7 miles away, 15 9-ton dump trucks, 1 10-ton 3-wheel roller, and 2 8-ton tandem rollers. The work called for an 8½-in. 1:3:5 concrete base, with expansion joints every 100 ft., 1½ in. of binder, and 2 in. of sheet asphalt topping. The contract included curbs and gutters, and was awarded at $317,000. The work proceeded, rain or shine, with raincoats issued to the men on rainy days, and was completed in 45 days, two days before the scheduled opening.

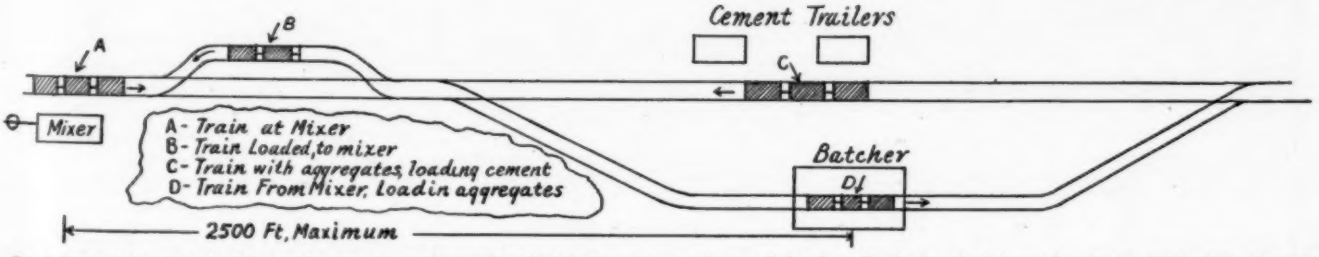
The contractors were the Commonwealth Improvement Company, Chicago, working under the direction of the Lincoln Park Commissioners. Walter Leninger is engineer for the contractors.

It is estimated that this improvement saves 15 to 20 minutes time for the motorist using it between his home and the downtown district.



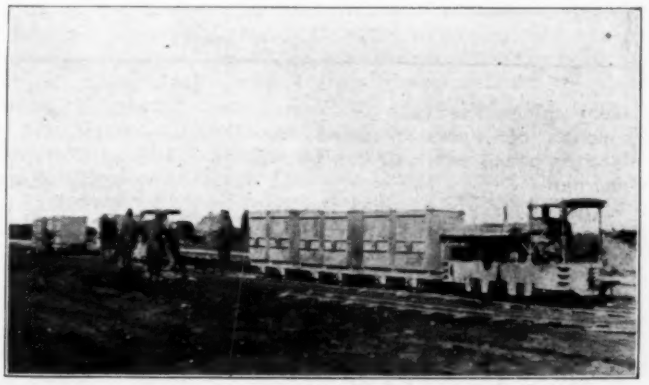
A Batch Going Into the Paver From Train Alongside

Crane Loading Aggregates Into Bin With Train Getting Loads



Track Layout Serving the Mixer, Showing Four Trains Handled by Two Locomotives. Only One Track Is Needed at the Paver With This System

Another View of Train Serving the Mixer



Loaded Train Pulling Into Siding, With Empty Returning to Batcher

Water Supply Data for Concrete Paving

The State Highway Department of Pennsylvania has compiled the following information for use in determining the sizes of pipe line to be used for the water supply on concrete paving projects. The information is based upon 50 per cent of the water being required for curing and 50 per cent being required for the mixer and subgrade curing. The department states that if calcium chloride is used for curing the amount of water required for the lengths paved per hour can be reduced one-half.

The tables given under the sizes of pipe lines are figured without modifications for head, and the table at the bottom of the tabulation gives the information for the correction for the head.

The tables are based on a requirement of 8,000 gal. of water for 100 ft. of paving apportioned as follows: ½ for curing, ¼ for subgrade, ¼ for mixer. The pavement is assumed to be 18 ft. wide. The head given is based on friction loss only. To this must be added the height of the outlet of the pipe above the source of supply.

The formula used is the Hazen-Williams Formula:

$$H = K \frac{lv^{1.87}}{d^{1.25}}$$ in which

H=loss of head due to friction
K=.00038
l=length of pipe in feet
v=velocity of water in feet per second
d=diameter of pipe in feet

A 2 -in. pipe=2.067 internal diameter.
A 2½-in. pipe=2.469 internal diameter.
A 3 -in. pipe=3.068 internal diameter.

How the Tables Are Used.—Example (1):

Estimated progress of paving 70 ft. per hour. Water required—5,600 gal. per hour.

Maximum water pressure in pump—150 lbs. per square inch.

Pipe 2-in. diameter, Pump 12 ft. above level of supply. Outlet 40 ft. above pump.

How far from the pump can the work be supplied?

150 lb. pressure=345 ft. head as per conversion table. 345—12—40=293 ft. net head.

The head required for 1 mile of pipe is 1083 ft. Distance water can be supplied $=\frac{293}{1083}=\frac{1}{4}$ mile.

Example (2):

Estimated progress of paving—70 ft. per hour.

Maximum water pressure in pump—500 lb. per sq. in.

Maximum distance water must be forced=2½ miles.

What size pipe is required?

500 lbs.=total water pressure available, which corresponds to 1,152 ft. head.

2-in. pipe under these conditions requires 2,706 ft. head or 1,175 lb. pressure and is too small.

2½-in. pipe is necessary and requires 1,116 ft. head; which corresponds to 484 lb. pressure.

A 3-inch pipe requires 377 ft. head which corresponds to 163 lb. pump pressure.

Example (3):

Estimated progress per hour=90 ft.

Distance water must be forced=2½ miles. What horsepower and pressure are required?

2-in. pipe requires 4,333 ft. head by table or 1,880 lb. pressure.

Water required=7,200 gal. per hr.=2 fal. per sec.=16.7 lbs. per sec.

16.7 by 4,333=72,360 ft. lb. per sec.÷550=132 horsepower.

2½-in. pipe would require 1,785 ft. head by table or 775 lbs. pressure.

16.7 by 1,785÷550=54 horsepower.

3-in. pipe would require 604 ft. head by table or 250 lbs. pressure.

16.7 by 604÷550=18 horsepower.

Water Supply Data

Loss of head due to friction in steel pipes for water used in paving

Length Paved Per Hr. Ft.	Gal. Water Required Per Hr.	V Feet Per Sec.	Length of Pipe ½ Mi.	1 Mi.	1½ Mi.	2 Mi.	2½ Mi.	3 Mi.
			2-inch Pipe					
.....	2000	3.188	79	158	237	316	395	474
.....	2400	3.825	111	222	333	444	556	667
.....	2800	4.463	148	296	445	593	741	889
.....	3200	5.100	190	381	571	761	952	1142
.....	3600	5.738	237	474	711	948	1186	1423
50	4000	6.37	288	577	866	1155	1444	1732
60	4800	7.65	406	812	1218	1624	2030	2436
70	5600	8.92	542	1083	1625	2167	2708	3250
80	6400	10.20	695	1391	2086	2781	3477	4172
90	7200	11.47	867	1733	2600	3466	4333	5200
100	8000	12.75	1055	2111	3166	4221	5277	6332
			2½-inch Pipe					
.....	2000	2.233	33	65	98	130	163	195
.....	2400	2.679	46	91	137	183	229	274
.....	2800	3.126	61	122	183	244	305	366
.....	3200	3.572	78	157	235	313	392	470
.....	3600	4.019	98	195	293	390	488	586
50	4000	4.47	119	238	357	476	595	714
60	4800	5.36	167	335	502	669	836	1004
70	5600	6.25	223	446	669	893	1116	1339
80	6400	7.15	286	573	859	1146	1432	1719
90	7200	8.04	357	714	1071	1428	1785	2142
100	8000	8.93	435	870	1304	1739	2174	2609
			3-inch Pipe					
.....	2000	1.448	11	22	33	44	55	66
.....	2400	1.737	16	31	47	62	78	93
.....	2800	2.027	21	41	62	83	104	124
.....	3200	2.316	27	53	80	106	133	159
.....	3600	2.606	33	66	99	132	166	199
50	4000	2.89	40	80	121	161	201	241
60	4800	3.47	57	113	170	226	283	339
70	5600	4.05	75	151	226	302	377	453
80	6400	4.63	97	194	291	388	485	581
90	7200	5.21	121	242	362	483	604	725
100	8000	5.79	147	294	441	588	736	882

Head Ft.	Pressure Per Sq. In.	Head Ft.	Pressure Per Sq. In.	Pressure Per Sq. In.	Head Ft.	Pressure Per Sq. In.	Head Ft.
10	4	200	87	4	9.2	50	115
20	9	300	130	5	11.5	60	138
30	13	400	174	6	13.8	70	161
40	17	500	217	7	16.1	80	184
50	22	600	260	8	18.4	90	207
60	26	700	304	9	20.7	100	230
70	30	800	347	10	23	200	461
80	35	900	391	20	46	300	691
90	39	1000	434	30	69	400	922
100	43	2000	868	40	92	500	1152

Delaware Right of Way Gains In 1926

During 1926 the state of Delaware secured new rights of way for 28 highway contracts, totaling 77.43 miles, at a cost of $47,341.79. It was necessary to condemn 17 properties at a total award of $4,853.10. Nine of these owners received the minimum award of six cents. The average cost per mile for the year was $611.41. This work necessitated writing 588 descriptions, the securing of 499 options and the execution of 372 deeds and 173 releases. The cost includes all work arising from the acquisition of the properties, including salaries, cost of resetting and erecting, moving buildings, digging new wells, land and crop damages and other costs.

Unusual Construction Methods on Carquinez Straits Bridge

Two Spans Constructed at Shore, Towed to Site, and Lifted Into Position by Counter-Weight System After Approach and Center Spans Were Erected

The construction of the $8,000,000 Carquinez Straits Bridge, at the head of San Francisco Bay, has involved some interesting construction features and methods. The structure, which will be opened on May 21, is of steel construction, with two cantilever spans of 1,100 ft. carried on one pier, and is said to be the longest highway bridge in the world. It is a connecting link in the Pacific Highway and provides, for the first time, a continuous highway along the Pacific Ocean from British Columbia to Mexico. It will eliminate the need for tourists detouring by way of interior California valleys, and will afford direct entry to the San Francisco Bay area from Canada, Oregon, Washington and western states.

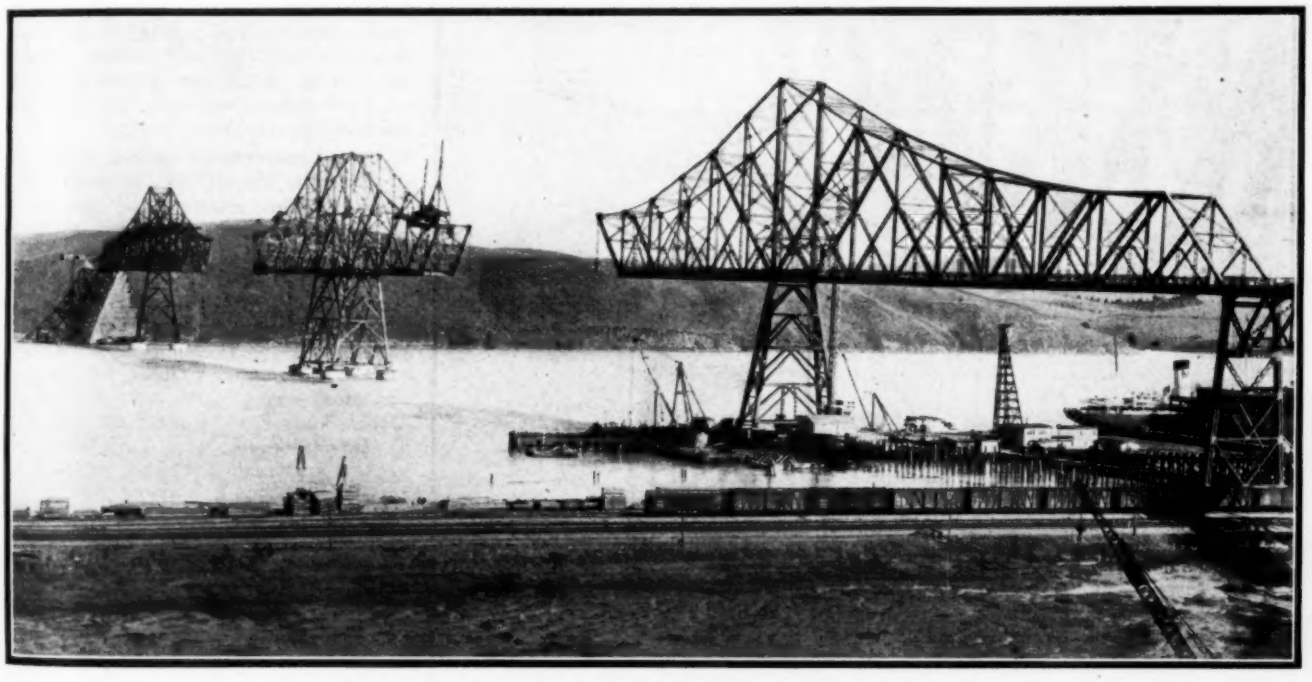
Length Four Thousand Feet.—The total length of the bridge is 4,482 ft., as compared with the Blackwell's Island, New York, bridge, which has a length of 3,724 ft. It extends from the north, or Vallejo shore to the south, or Crockett side of Carquinez Straits. The clearance above mean high water level is 135 ft., sufficient to provide for any shipping.

Tower Supports.—The bridge is supported by three center towers each 325 ft. in height above mean low water level. The center towers are 150 ft. wide, extend 185 ft. above the floor of the bridge, and support two arms each 500 ft. long. The roadway is 30 ft. wide, affording three traffic lanes. It was planned for a traffic flow of 1,000,000 vehicles annually. The bridge is carried on concrete caisson piers extending to rock. These were sunk by means of concrete-filled timber cribs about 110 ft. high, jetted into position. This part of the work alone cost more than one and one-half million dollars, with a unit cost for concrete in place of $35.85 a yard.

Construction Procedure.—The work was divided into six sections; the construction of 2½ miles of highway, the construction of the caissons and steel piers, the construction of the south approach span and tower, the construction of the north approach span and tower, the construction of the central tower and portions of the two cantilever arms, and the construction and placing of the two cantilever high spans in the gaps on either side of the central section. These latter spans were each 450 ft. long, and their erection presented an interesting engineering problem.

Cantilever Spans.—These two sections were fabricated on the shore of the straits and then floated into place below the positions that they were to occupy—after the rest of the steel had been erected. When towed into position they were raised into place and field bolted while the rivets were being driven.

To raise these spans a counterbalance system was used. Four boxes, each 13 ft. by 13 ft. by 21 ft., were built and suspended by ½ in. steel wire rope passing through snatch blocks on the end members already erected, and passing to a series of drum hoists, and then down to the span to be raised. The boxes were then each filled with 200 tons of sand, leaving but little work for the hoists to do, since each span weighed about 750 tons.



General view of the Carquinez Straits Bridge Before Cantilever Spans Were Completed.

Hoisting.—The weight of the boxes, plus the sand, was considered slightly greater than the weight of the span to be lifted, plus the weight of the hoisting cables. Thus when the boxes were released and the hoists operated, inertia was readily overcome and the descent of the counterweights easily pulled the span up into place, where field bolts were quickly inserted and the spans thus carried by the rest of the structure. To prevent rocking or overturning during this delicate operation, a complicated lashing system of hemp ropes was utilized, tying the top of the span to the hoisting cables which were attached to the ends of the bottom chords.

Moving from Wharf.—The problem of moving these spans from the fabrication wharf was solved in an interesting manner. The wharf had been so built with timber bents that only the ends of the span were thus supported. When ready for erection steel barges were floated underneath the span, and 8 500-ton hydraulic ram jacks resting on the barges were used to lift the span clear of the wharf. As the span was lifted from its supports by these jacks, cribbing was erected on the barge to carry the span. The total lift was about 11 ft. When adequate clearance was thus gained, and the entire weight carried by the barges, a tug took the unit in tow and ran upstream beyond the bridge, and then downstream again until the span was located correctly below the gap which it was to fill. Four barges anchored in the strait served as anchorages for the barges carrying the span until it could be hoisted into place.

The hoisting cables were next attached. By this time the tide had begun to fall, and this lowering of the barges took up all slack in the cables, permitting the hoisting to begin without more troublesome methods being used to take up this slack.

It took but 48 minutes from the time the span cleared the barges until the last field bolt was in place, the 750-ton span being raised 135 ft. in that time.

Organization. — Executives responsible for the work were officials of the American Bridge Company and its subsidiary, the United States Steel Products Company. Richard Khuen, general manager of the erection department of the bridge company, was in general charge of the work, with K. L. Strickland, division erection manager for the subsidiary company, as his chief assistant. C. F. Goodrich was also on hand. He is head of the board of designers and worked out the details of the bridge construction. Then there was Prof. Charles Derleth, Jr., of the University of California, chief engineer and designer for the American Toll Bridge Company, who worked out the first conception of the bridge and has generally supervised the work since its start.

Working under the immediate direction of Strickland were, among others, A. F. McLane, resident engineer; E. E. McKeen and George Walton, assistant engineers; Frank Stangle, general foreman, and George Collins, assistant foreman.

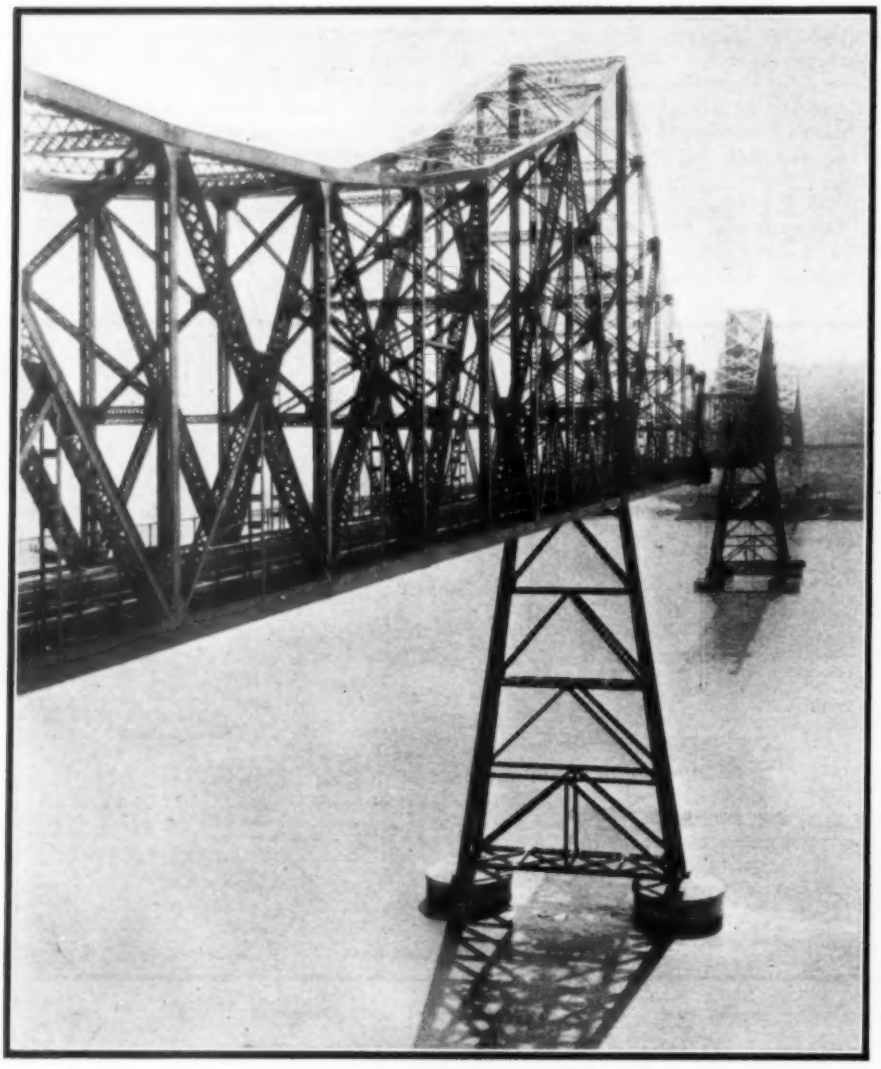
One of the important figures in the work was Ernest E. Ecklund, assistant meteorologist of the United States Weather Bureau in San Francisco. He had been watching weather, wind and tide conditions since April 24 and for two days and nights had remained at his post to detect any change in the weather. Previous to the lifting of the span, he furnished a weather forecast that proved accurate as to rain, cloudiness, sunshine and wind.

The work of these men was carried on under critical eyes. Among the forty or fifty boats which dotted the straits during the entire operation was a government engineering power yacht, which carried as passengers some of the most prominent men in engineering circles throughout the country, gathered to witness the hoisting of the spans. Then there were several private parties, including experts from Stanford and California universities. One of the largest of the boats housed a party of legislators who made the trip from Sacramento, the state capital.

Three government patrol boats, one of them the "Swift" of the coast guard service, under command of Lieutenant McLane, patrolled the straits regulating traffic

Prof. Charles E. Derleth, Jr., of the University of California, heads the bridge engineering staff for the American Toll Bridge Company as chief engineer and designer Other members of the engineering staff are: William H. Burr, New York consulting engineer; D. B. Steinman, New York designing engineer; George J. Calder, resident engineer; Prof. C. L. Cory, University of California, chief consulting electrical engineer; Prof. Andrew C. Lawson, head of the University of California geology department, and his son, Werner Lawson, of the same department, who were called in for expert advice as to geologic structure which would insure the safety of the bridge foundation, and William B. Gester, engineer handling the inspection of materials used.

The bridge was financed by a public security issue. Interest on securities, redemption of principal, profits and upkeep will come from tolls to be charged foot and automobile traffic. At the end of 20 years the bridge becomes the property jointly of Contra Costa County and Solano County, which California counties granted franchises for the structure.



Closeup Showing Several Panels in Shore Span

Can Still Spend Three Million.—The Virginia State Highway Commission, after awarding contracts totaling $6,600,000 since Jan. 1, yet has three million dollars for further contracts during the year.

Paving Along Street Railway Tracks

Its Evolution and Future Discussed in Paper Presented at Annual Meeting of Illinois Society of Engineers

By J. I. CATHERMAN
Engineer, Maintenance of Way, Illinois Traction System

Back in 1888 the first electrified city railway began operation in the city of Richmond, Va. Before that, old Dobbin held sway as the motive power of the street car. During the 39 years intervening the electric railway has shown wonderful strides in every phase of its operation.

New problems have cropped up continually. In rolling stock and track design have been the most notable changes. In paving there has also been made some wonderful improvements. We have gone from the very small car seating a dozen or so people to one seating 56 people, and back again to the one-man car seating 30 people; from the car weighing 4 or 5 tons to the car weighing 18 tons and back again to the car weighing 8 or 10 tons.

Track construction has gone from the old 40 lb. and 60 lb Tee rail up to the 9 in. girder rail weighing as much as 174 lb. per yard. From red oak ties to treated ties each protected with tie plates, all steel ties and semi-steel ties, rail fillers, from common angle bars to welded joints, from a few inches of gravel ballast, in many cases, to a foot of stone ballast, to concrete slabs beneath that ballast, or to a sub-structure encased entirely in concrete. And lastly, but not least by any means, from a paving structure consisting of a layer or two of brick laid on a sand or gravel bed, to brick filled with asphalt, to granite blocks or to a track structure entirely encased in concrete paving. The paving problem which started when old Dobbin trotted down the center of the track is still with them and has become an increasingly serious one as the years have gone by.

The track structure itself is the first consideration and to it we must first turn our attention. Upon its proper construction depends, to a very great extent, the life of the pavement.

Specifications as Related to the Street Railway Track.—As engineers I believe that you can readily see that no particular set of specifications can be set up to cover street railway track construction. Barely any two cities have the same natural problems, so that to set up a standard set of specifications and say to the industry "you must do this here" and "you must do that there" would be as futile and ridiculous as to say that by assembling together a number of definite, but different units, there can be manufactured one best automobile or one best radio.

Such a standard specification, or standard design, to cover all cities, and all conditions, would necessarily have to be so rigid and so broad in its scope that it would work an unnecessary financial hardship on many of our properties and would probably not even give the best results to many properties who really were financially able to comply with them. Not only must economy in first cost be considered, but economy in future maintenance as well. Track, just as anything else, will wear out, and must at certain periods be completely rebuilt and it should be so designed as to give the maximum amount of life at the most economical cost, the minimum of maintenance required and a maximum amount of salvage when reconstruction does finally become necessary.

Experience, both of ourselves, and of others, is the guide to which we must turn and this experience must be based on personal contacts and personal observation over a period of years and under all sorts of local conditions, and not upon the sometimes highly camouflaged and glossy reports we often receive.

The first problem which confronts the street railway engineer is that of weight of rolling stock, the volume of traffic and the probable future of such traffic. Upon these three things depends the entire design of the track structure.

Soil Conditions.—The next factor is that of the condition of the soil upon which the track is to be constructed. This phase of the subject is one to which too little attention is paid and has unquestionably been responsible for the complete failure of many pieces of railway track. The soil in barely any two of our cities is exactly alike and each individual condition must be studied if the best results are to be obtained. A soil which under ordinary natural conditions would not support a track structure might be made to support it if proper precautions are used. Stone may be rolled into the sub-grade to bind it together before the ballast is laid, a concrete slab may be installed to support the ballast or many other schemes may be carried out. With them all, however, the drainage problem must be considered and proper precautions must be taken to so drain the sub-grade, or road-bed, that it may at all times be free of moisture. A few dollars spent in drainage will return themselves a hundred fold when future maintenance is considered.

The Matter of Economy.—The third, and probably the most important factor, is the one of economy. This factor confronts the railway engineer continually and in meeting this requirement he is called upon to exercise his greatest ingenuity. Too often indeed, the engineer stands as a buffer between his management and the local board of improvements. The street railway manager has his own ideas as to how much money can be put into a piece of track, the local board has set ideas, usually dictated by their engineer, and the railway engineer also has his own ideas. In striking a happy medium he is often put to his wits ends in obtaining a job that will stand up under the traffic to which it will be subjected, require a minimum of maintenance and still satisfy all those concerned.

Local conditions also affect this economy bogey. One engineer may say that 8 in. of stone ballast is all that is necessary, another may say a foot is required, or that the ties should be entirely encased in a slab of concrete in order to obtain the best results. Both may be right. Their local sub-soil conditions and the volume of traffic over their track absolutely govern these features.

The Ties.—After the sub-grade is prepared and the ballast installed we have the ties. One engineer may think an untreated white oak tie is sufficient, that a more expensive tie is unnecessary; another may think that to construct track of untreated ties is nothing short of a crime. My personal experience in constructing track for heavy electric traction, is that for such traffic, sawed 6 in. x 8 in. or 7 in. x 9 in. red oak ties, creosoted, either by the full cell or empty cell process, and tie plated is the proper class of tie to be used in pavement. For city railway service only, the all steel or semi-steel tie, encased entirely in a slab of concrete will provide a base of sufficient strength to carry traffic, is an economical construction and will have a life as long as the wearing surface of the pavement at least, and possibly longer. Again the matter of economy pops up. White oak ties or some other good tie may be obtained locally in quantities, while the treated tie or the steel tie may have to come from a considerable distance and its cost by the time it reaches the job, may be excessively

high. It is then up to the engineer to make the best of his opportunity, provide a well drained road-bed, and surround the tie with such other conditions that it will give a maximum of service.

The Rail.—Our next problem is the rail and it is here that Heinz with his 57 varieties has nothing on the railway industry. Rail can be found suitable for any weight of rolling stock, for any kind of wheel flanges; rails that will comply with franchise requirements and the desires and arguments of city engineers and local boards of improvement, and rails that wont, and the manufacturer will roll almost any kind you want. One of the greatest blessings that could come to the railway industry would be a committee of our railway organizations with courage enough to set forth specifications covering a few types of rails, rails that would take care of any kind of traffic and under any kind of conditions, and added to them, manufacturers who would say "we will roll these rails and no other." I am firmly of the opinion that all of the requirements of all the electric railways of the country could be centered on possibly a dozen types of rail. Prices would be decreased, deliveries would be enhanced and the benefits to be derived would be unlimited both to the manufacturer and to the user. I have certain set ideas of my own in this regard. To go deeply into this phase of the subject might simply open up an argument which would take up more time than is available at this meeting.

Looking at the structure of the track in general. As I have said before, no one set of specifications can or will meet all conditions. Each property has its own problem, it may be in sub-soil conditions, it may be weight of equipment, it may be a particular franchise requirement, or it may be entirely one of economy, or possibly a combination of all. The problem may simply be the desire of the local management to build for their own immediate future and to leave the period of 25 or 30 years hence to their successor. This spirit of alleged economy too often, in the past, has governed our railway construction, but our railway managers today, I believe, look at the problem in a different light and are building not only for themselves, but the best they know how.

Track Paving.—We now come to the peak, or culmination of our discussion. That is the paving along our track, the wearing surface, if you please, of the entire track structure, and its subsequent maintenance. Again we are confronted with another 57 varieties. However, there are only a few outstanding types which are in general use today and it is on these that our discussion will be centered.

A concrete pavement in a track area can be installed at a rather reasonable cost and when first laid it looks fine. However, rails have a peculiar habit of breaking, joints fall down, unless welded and then they will sometimes fail, and the concrete must then be taken up in order to make repairs. It would be a waste of time to tell you men what then happens. You know as well as I, that no concrete pavement can be satisfactorily patched, especially that along a street railway track. In addition when entire rehabilitation is necessary the salvage from the paving is nil.

Brick, wood-block and granite block are three other types of paving found in general use today. The first and third types, I am convinced, are the most efficient and give the greatest degree of satisfaction. The use of either one is governed, to a great extent, by the locality, or the convenience with which it is obtained.

Wood-block, during the past 20 years or so, has found a wide and extensive use along railway tracks, but it has also shown the greatest number of failures of the three types mentioned. Exposed to the heat of sun, and other extreme weather conditions, the lighter oils will, after a few years, evaporate, and then the block is ready to take up moisture, which is usually accompanied by very disastrous results. I firmly believe that many of these failures could be avoided, and the pavement given an additional lease on life if after about 5 or 6 years of service the surface was given a good spraying of creosote oil or a covering of paving pitch. This will keep the blocks and the spaces between filled with oil and prevent the infiltration of moisture.

Granite blocks, although probably the more expensive, will undoubtedly provide the best wearing surface, stand up longer along railway rails and have the largest salvage value of any type of paving in general use today.

Next to granite block I believe the most satisfactory pavement for a street railway is a good, hard burned shale brick with asphalt filler. This brick need be no thicker than 3 in. and the sand cushion no deeper than ¾ in. If laid properly and with the proper foundation, I believe such a pavement will provide the best appearing street, the most durable, give the longest life and provide the greatest salvage, excepting granite block, of any of the types in common use today on the average city property. On our large city properties, granite block, although the first cost is high, will outshine the brick pavement in practically all respects; this is due, only, to the heavier vehicular traffic, under which granite has the greater wearing power.

Asphalt has also been used to some extent, but experience has shown where laid in a track area at least one or more rows of brick or stone block should be laid next to the rails. When laid in direct contact with the rails, the tendency to heave and disintegrate is greater in the asphalt pavement than in most any other type.

Effect of Other Utilities on Track Maintenance Problems.—If no other utilities occupied our streets, the street railway engineer's problem would be much simplified. The street railway, however, is only one of seven or eight utilities occupying our city streets. Some streets carry exceedingly large sewers, water pipes, telephone and telegraph cable conduits, etc. All of them have manholes at frequent intervals and to construct special track work layouts to dodge all of these openings is sometimes a pretty problem and their very presence usually causes great difficulty in properly constructing and maintaining the track and paving surface. Why, I will ask, could not the sidewalk or boulevard spaces be more generally used for the location of such utilities. Frequent inspections and repair of such utilities would then not affect the street pavement. This item may seem somewhat foreign to the street railway problem, but I assure you that such is not the case, for all too frequently ditches are cut under tracks, improperly filled, track settles, paving settles and breaks up, and the street railway is the goat.

I simply call this phase of the problem to your attention, as I believe that closer co-operation should exist between the city engineer, the railway engineers, and the engineers or managers of the other local utilities that these local aggravations may be eliminated.

Average Unit Prices in Iowa

The following table from the Service Bulletin of the Iowa State Highway Commission shows the average unit prices for 1925 and 1926 on various types of work and necessary materials used in road building:

	1925	1926
Paving, per sq. yd.	$2.4528	$2.45
Graveling, per cu. yd.*	.3929	.3972
Graveling, per unit†	.0762	.0784
Grading	.2227	.2493
Bridging, concrete, per cu. yd. in place	22.72	
Structural steel, erected I-beams	4.54	4.627
Structural steel f.o.b. county	3.50	3.656
Structural steel, trusses erected	6.70	6.547
Structura steel f.o.b. county	4.912	5.48
Reinforcing steel ⅝-in. in round new billet	2.788	2.773
Reinforcing steel ⅞-in. in round new billet	2.589	2.669
Lumber, 3 ft. x 12 ft. standard sawed Douglas fir	35.04	33.68
Lumber, 3 ft. x 12 ft. full sawed Douglas fir	39.20	37.98
Lumber, standard sawed white oak	39.25	45.50
Piling, 16 ft. red cedar	.261	.25
Piling, 16 ft. cypress	.187	.177
Cement dealers' net price, f.o.b. Cedar Rapids	2.44	2.385
Corrugated culverts, 24 in. L. C. L., f.o.b. county	1.419	1.71

*Per cu. yd. screening, loading, hauling 1 mile and spreading.
†Per unit of additional half mile haul.

Marking Accident Locations.—Large white crosses will hereafter mark the spots on Ohio highways wherever fatal accidents have occurred.

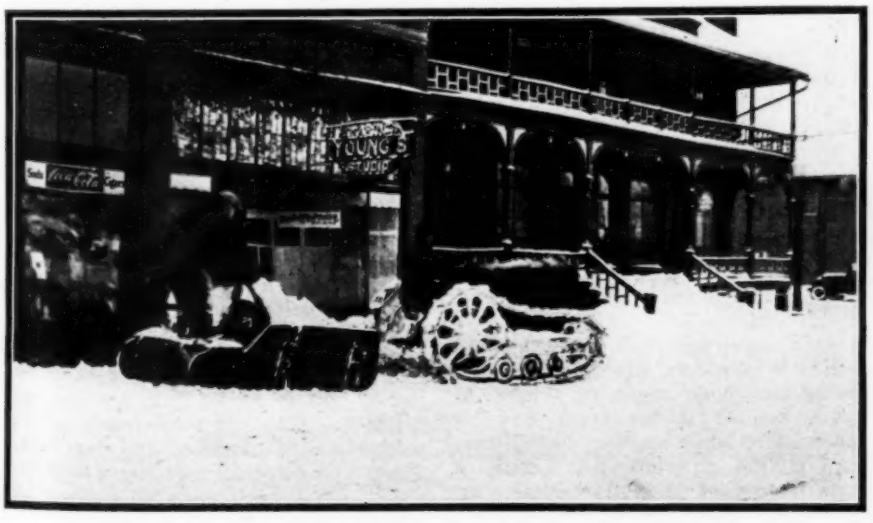
Snow Remover Saves 75 Per Cent In Sault Ste. Marie

According to City Manager Henry A. Sherman of Sault Ste. Marie, Michigan, a unique snow remover, utilized in clearing the streets in the business section of that community, has saved at least 75 per cent over that of loading the snow by hand into trucks or sleighs. This device, which has a capacity of 2½ to 3 cubic yards of packed snow, is pulled by a Fordson tractor, with one man on the machine and another driving the tractor.

The snow is first winrowed by a grader equipped with runners, and this loosened snow is then picked up by the remover. As soon as a load is accumulated it is taken to the nearest vacant lot, preferably on a side street, and dumped. The door at the back end of the machine makes it easy, it is said, to dump the load while moving, without stopping, the machine then moves back to the street for another load. The chief advantage of this method, according to Mr. Sherman, is that the machine loads and unloads itself in a continuous operation, effecting a saving in labor. A load every two minutes was found to be the average speed of operation last winter.

On all residential streets, the city uses a Wausau plow pushed by a Monarch ten-ton tractor, pushing the snow back to the curb on each side of the street.

This Type of Plow is Used on Residential Streets in Sault Ste. Marie.



The Snow Scoop Used in Clearing Business Streets in Sault Ste. Marie.

Sunset Route Trees to Be Preserved. —In the course of relocating the Sunset Route on the west side of Rainier National Park, the United States Bureau of Public Roads has ordered that only the actual right of way be cleared, and that bordering trees be unmolested in order to preserve the scenic value of the highway and to retain the museum of forestry that the present stand of timber constitutes.

Cost of Subgrade and Earth Shoulders

Mr. A. E. Hunter gives the following data in March 10 Public Construction News, the official publication of the Illinois Association of Highway and Municipal Contractors:

"The question of earth work of any nature has not been very fully discussed by our Association. We did not feel that the subject was unimportant but the larger question of pavement proper involves so much expenditure and has been on such an unsound basis that we deemed it advisable to direct our efforts toward its solution, and this has delayed suggestions concerning earth work operations.

"By a chance coincidence we were able recently to make a comparison of the figures indicated in our estimate with actual records kept by a grading contractor over a period of some two or three years. A glance at the figures used in our estimate for 16 miles of work shows that the total cost of subgrade and shoulder work was $24,780 for this section which, reduced to cost per square yard, is 14.7 ct. directly chargeable to each square yard of pavement.

"Following is the digest of figures secured from a grading contractor of wide experience covering the items of subgrade and earth shoulders of seven jobs for the year 1925:

Section:	1 ct	2 ct	3 ct	4 ct	5 ct	6 ct	7 ct	avg ct
Shoulders	7.5	7.4	8.0	8.0	7.0	6.0	6.0	7.1
Subgrade	7.5	6.2	8.0	6.0	8.0	7.0	7.3	7.3

Total average 14.4 ct. per square yard of slab.

"It would seem that the actual record of activities kept on these seven sections should be fairly representative as to cost.

"This information concerning the cost of earth shoulders and subgrade was presented by this contractor in convention. On the same afternoon our own estimated cost for similar items was presented for discussion. It is of particular interest to note that the bases for these two separate sources of information were entirely separate and distinct. It is true they were collected from the same general field of work, but by different individuals each of whom had no knowledge of the other's activities."

Ford Builds Cutoff for State Road

According to the New York Times, Henry Ford, is constructing a detour to divert traffic from the portion of the state road from Boston to Worcester, Mass., that runs past his Wayside Inn. The new cutoff, which the motor magnate intends to present to the State of Massachusetts, will eliminate a dangerous curve and take tourists to the top of a knoll affording a view of the Inn, and back to the older route, without passing the Inn.

Keeping Road Maintenance Costs

System Used in Division Offices of Ohio State Highway Department Described in Paper Presented At Ohio Road School

By H. C. WILSON

The subject of "Office Cost Records" is one on which volumes might be written if one attempted to go into all the details or touched on every phase of the subject. This article will deal only with the records kept by the division offices of the Division of Highways which are considered the most important part of the cost keeping because most of the repair and maintenance work is supervised from division headquarters.

The cost records are divided nominally into two groups, namely: "Information Records" and "Financial Records." Of these the financial records are of greater importance, as all the work is controlled by a budget, a certain amount of money being set aside for each specific purpose. The fact that a state highway department is a money spending organization only, simplifies the cost keeping job considerably, as there is no need of recording both debits and credits, as does a large manufacturing or sales organization.

Financial Records.—The financial records show at all times how much money has been spent and just how much remains to be spent on a given job. The projects covered by the budget on which financial records are kept are of various kinds. General division charges include route marking, new equipment, supplies and repairs. County charges have similar items. Also there are sectional charges covering such items as surface, roadbed, and other parts of a job.

Whenever it is desired to determine the status of the finances on a particular section, account must be taken not only of the payrolls and invoices which have actually been paid, but also of the materials ordered, as some of these materials are actually incorporated in the work and must be paid for. Hence the necessity for what is termed a "control account."

Control Account.—The control account is the total of all paid invoices and payrolls, plus any outstanding orders for materials. All immediately contemplated purchases of material appear on this account except those made in the field without a regular departmental order having been issued. For this reason, field orders are kept to an absolute minimum. The control account does not show the actual distribution of charges, but is simply the sum of all charges against a certain division, county, or special account that is operating toward a budget figure that must not be exceeded.

In addition to the general control account a record of actual expenditures must be kept. Upon this ledger is entered the actual amount of payrolls and invoices, a separate account being carried for each section or special charge. Each charge is also distributed to subcharges which are given file numbers and letters. This code distribution shows at a glance whether a new piece of equipment, for instance, was for route marking, surface treatment, or some other purpose.

Information Records.—In keeping the information records or unit cost records there is difficulty in keeping tabulations as systematic and comprehensive as is possible with money expenditures. These records depend largely on the initiative of the various division officers and maintenance superintendents. For example, although the total cost of erecting a piece of guardrail is known, the cost per foot is not available unless a record is always kept of the number of lineal feet erected. Then to this cost must be added general charges.

When the absolute cost of any operation is wanted the problem arises of deciding what overhead or miscellaneous charges should be apportioned to this or that particular item. With the great variety of operations performed, it is seen that obtaining absolutely correct unit cost data is impossible. But a well controlled department can figure enough for all practical purposes.

Distribution of Overhead.—Undoubtedly the distribution of overhead is the most difficult part of keeping a unit cost record. A cost record which does not include overhead is only 50 per cent complete and means little, practically.

The Division of Highways in 1926 has outlined a method of distributing general charge over all items on which unit costs are desired.

It is well to note that the item of superintendence is sometimes neglected in making charges on payrolls. One section of work on which considerable money has been spent may have no figure against it for many days of supervision, while another section may have all the superintendent's time. A little more care in allocating personal time on the part of every executive will make costs more accurate.

Accurate Reporting Necessary.—Care in charging requisitions for materials and in distributing charges on invoices is required of everyone, including superintendents themselves, if proper distribution in the office is to be expected. "Office Cost Records" are largely an accumulation of comparatively small charges which are segregated according to the charges made by the superintendent out on the job.

The cost records on maintenance out on the road are largely the result of observation made by superintendents on the cost of typical operations. At the end of each season every superintendent reports his average unit costs for the season for such items as dragging, crushing stone, cutting weeds, and whitewashing.

A small discrepancy in the amount charged to any particular item may seem to be minor importance to the man in the field, but a few moments consideration will show that in the last analysis it is all these small items added together that make up the millions of dollars the State of Ohio spends annually on maintenance. An accumulated error of 10 per cent would in itself amount to nearly a million dollars.

However, the exact determination of costs on road work never will be possible, as it is in a manufacturing plant engaged in standardized production. The work is too diversified and the same kind of work is never performed twice under identical conditions.

Keeping Tab on Equipment and Stock.—Shop records of the operation and repair costs of motor equipment are probably the most complete of any, as the handling of equipment is a more exact procedure than the handling of materials.

A card index system is used from which any piece of equipment can be located at any time. A card is made out for each piece showing all such details as make, type of body, capacity, and license number. All transfers are recorded on the backs of the cards. If, for instance, a truck is transferred from one superintendent to another, its card is taken to the new user's file. The card, then, is always in the file of the person charged with the truck.

In addition, a cost record on each piece of equipment is kept which shows at the end of each year the mileage covered, the gallons of fuel and oil consumed, repairs, and other operation costs. The fuel record is kept and turned in weekly by the drivers, regardless of whether the equipment is working or not, so as to make the reports complete. Time out for idleness or repairs is also reported in this way. Thus, there are 52 cost cards sent in annually for each piece of equipment, whether it is a pump or an engineer's motor car.

Maintenance has arrived, in many states, to nearly its ultimate importance involving upkeep and repairs to a great mileage that is nearing replacement. Ohio is one of these states, and this important end of highway service has been handled with the accurate keeping of costs that is necessary to the efficiency of any large-scale operation.

The Trend of Highway Design

Practices of Various State Highway Departments Reviewed in March Public Roads

By A. G. BRUCE and R. D. BROWN

Highway Engineer and Associate Highway Engineer, U. S. Bureau of Public Roads

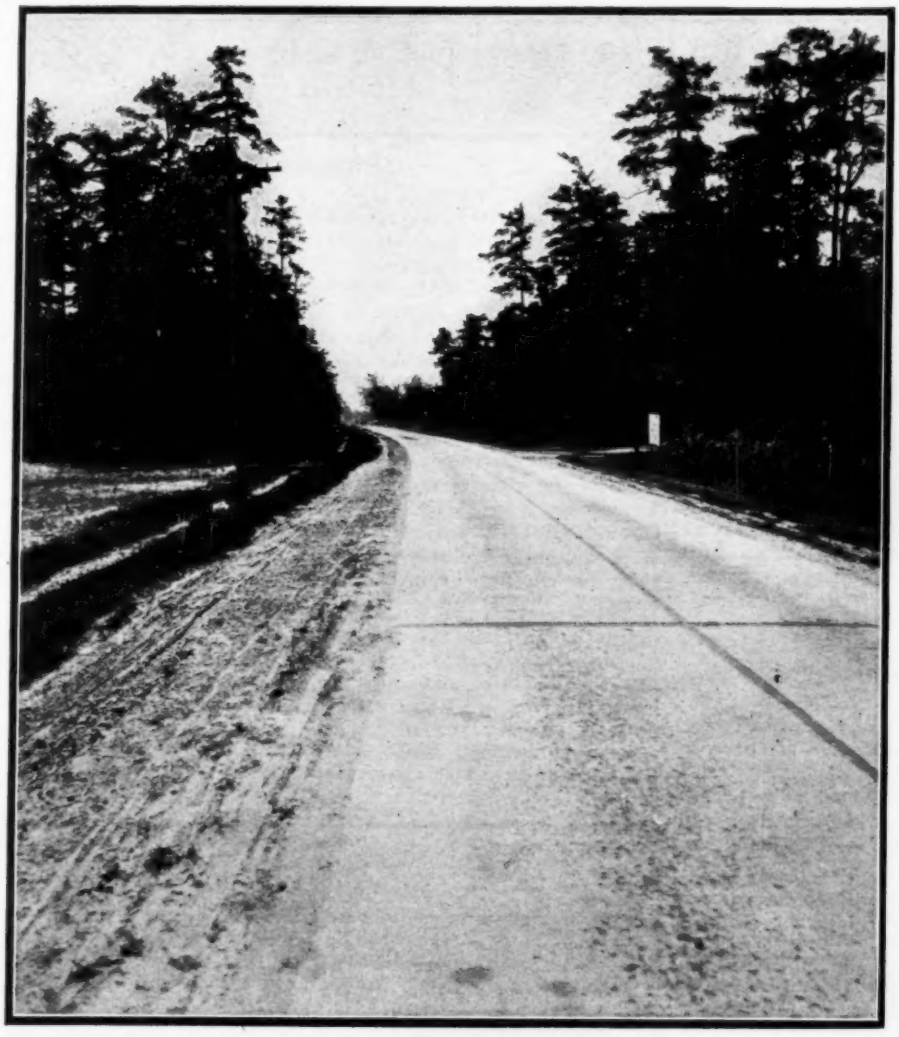
To one familiar with the practice of the state highway departments the changes which have been made in the design of highways during recent years appear as no less remarkable than the notable changes in the volume and character of traffic by which they have been called forth. The general character of these changes is perhaps already well known to all highway engineers, but it is thought that a review in some detail of the practices now employed by each of the state highway departments, and their evolution during the past several years will be of interest as indicating the various shades of opinion on doubtful points and the degree of standardization obtained.

Opportunity for such a review is presented by the plans received from all states by the Bureau of Public Roads for Federal-aid projects, and the following analysis is based upon a large number of such plans received during the last six years:

Crown.—Nearly all the states now require that hard-surfaced pavements shall meet a surface trueness test, and this has resulted in greater care in finishing and has permitted a reduction in crown until the pavement now appears to be almost flat. The crown on cement concrete, brick, sheet asphalt, or any of the bituminous concrete pavements on rigid foundations is rarely more than ¼ in. per foot. Some states have adopted ⅛ in. per foot, and two states use 1/10 in. per foot. The trend of practice is toward the latter amount, and it is probable that a 1-in. crown for a 20-ft. hard pavement will soon be the prevailing practice. On sand-clay, gravel, and waterbound macadam roads the prevailing crown is ½ in. per foot and on bituminous macadam roads ⅜ in. per foot is quite general.

Curvature.—The trend toward easy horizontal curves and longer vertical curves is very apparent. A few years ago curves of 150 and 200 ft. radius were common because of right-of-way difficulties and grading costs. Both engineering opinion and public sentiment have changed considerably and now the radius is seldom less than 500 ft. and some states have adopted 1,000 ft. as the standard radius for main highways. Tangents at least 100 ft. long are usually provided at bridges and between reverse curves when topography permits.

Vertical Curves.—The length of vertical curve has increased with the volume and speed of traffic which have made necessary greater sight distances. A rule used in many cases is that the length of vertical curve in stations shall equal one-half the algebraic difference of the approach grades in per cent. This rule results in a sight distance of approximately 450 ft., but on roads of primary importance the minimum sight distance on convex vertical curves is generally 500 ft. and on secondary roads not less than 350 ft. Vertical curves are now used at all changes of grade on hard pavements, and on gravel and macadam, where the algebraic difference in grades is more than 0.5 per cent.



A Modern Concrete Pavement. The Longitudinal Joint Prevents Irregular Longitudinal Cracks and Acts as a Guide Line for Traffic.

Grades and Alignment.—The 1926 designs showed a continued upward trend of standards of alignment. The alignment is becoming straighter. Relocation of crooked roads and the use of long, easy curves are becoming common. The grades have not been appreciably reduced; in fact, there appear to be more short, steep grades than heretofore. This is due in part to the fact that engineers now prefer to avoid sharp curvature even at the expense of steeper grades. There is no uniformity in the ruling grades adopted by the various states, but 5 per cent seems to be the prevailing practice. Grades of 7 per cent, however, are not uncommon, and in the Appalachian Mountain section short 9 per cent grades are still considered necessary.

Compensation of Grades.—There is no general acceptance of the theory that grades should be compensated for curvature on the modern highway designed for motor-driven traffic. This feature in grade design is, however, common in the Pacific Coast States.

Good practice seems to indicate that grades in excess of 5 per cent should be compensated on curves of less than 500-ft. radius. The amount of compensation necessary depends upon several factors, including the length of the approach grade and its rate, the degree of curvature, length of curve, the amount of superelevation, the sight distance, and the general character of traffic expected. A simple rule that appears to have considerable merit is to compensate grades over 5 per cent on all curves of less than 500-ft. radius at the rate of 0.5 per cent for each 50-ft. reduction in the radius below 500 ft.

Superelevation and Widening.—Superelevation and widening of curves is now universally practiced, but there is no agreement in formula or method in the various states. A few states superelevate the roadway on all curves sharper than 1°, but the prevailing practice is decidedly more conservative. The average practice seems to be to superelevate all curves of less than 2,000-ft. radius and to widen all curves of less than 800-ft. radius. A maximum superelevation of 1 in. per foot of width, and a maximum widening of 4 ft. represent the prevailing practice. The subcommittee on design of the American Association of State Highway Officials recommends, as a rule for widening, the formula suggested by J. T. Voshell, district engineer of the Bureau of Public Roads:

$$W = 2\,(R - \sqrt{R^2 - L^2}) + \frac{35}{R}$$

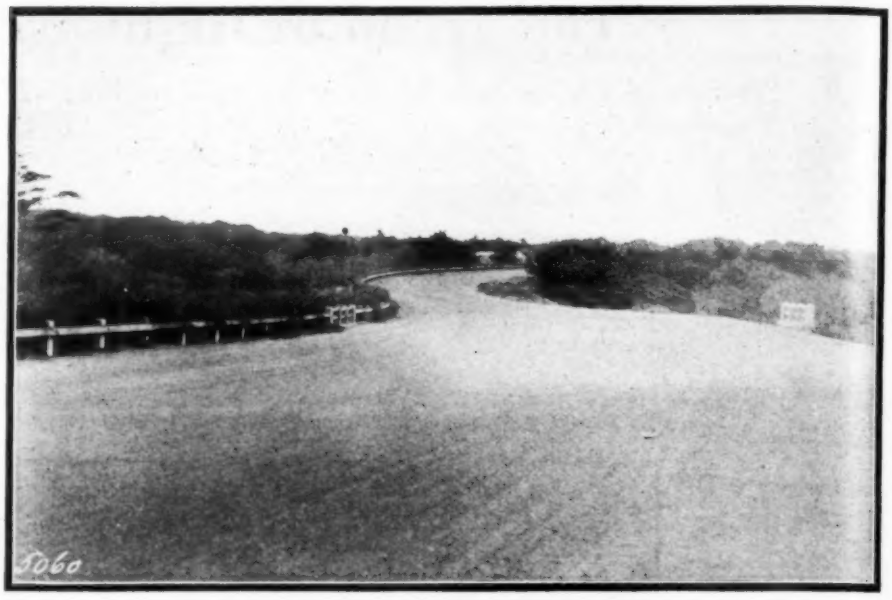
In which W = Widening in feet.
R = Radius of curve in feet.
L = Wheel base of vehicle in feet (20 feet recommended).

The same committee rocommends for superelevation the formula

$$E = 0.067\,\frac{V^2}{R}$$

In which E = Superelevation in feet per foot of width.
V = Velocity in miles per hour (35 recommended).
R = Radius of curve in feet.

Width.—Eighteen feet still predominates as the width of pavement on Federal-aid projects although pavements 20 ft. wide and wider are not uncommon. Of the 3,643 miles of surfaced Federal-aid road brought to completion in the six months period preceding Feb. 1, 1927, approximately half had 18-ft. surfacing. Eight hundred and thirty-one miles were less than 18 ft. wide, 1,809 miles were of 18-ft. width, 900 miles were between 19 and 24 ft. wide, 79 miles between 25 and 30 ft. wide, and there were 24 miles of unusual construction not falling in the above classification.

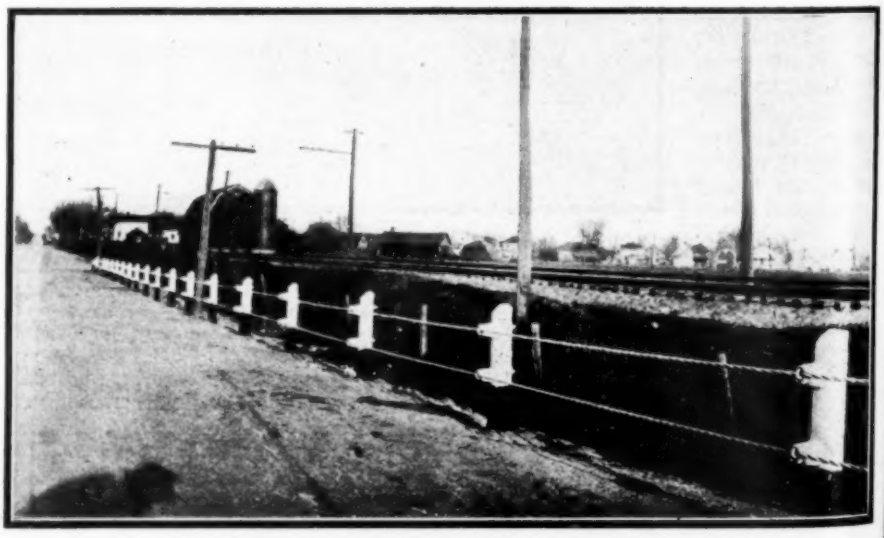


Superelevation and Widening in a Gravel Road

Subgrade.—A majority of the states give little or no consideration to variations in the character of the subgrade, using the same pavement design throughout each project. A few consider subgrade influence and compensate for it in varying degrees and manners.

Guard Rail.—In the minor features of highway design, such as culverts, guard rail, curbs, shoulders, etc., there do not appear to be any marked developments during the past year. The trend in guard-rail design continues to be toward the steel cable and woven wire and away from the wooden type. Where local conditions justify wooden guard rail, the plan of placing the rail at the elevation of the vehicle hub is gaining in favor. Some states are using steel and concrete guard-rail posts, but the prevailing practice is to use wooden posts. Some have adopted a new arrangement for fastening the wire cable to the post. Instead of running the cable through the post or bolting it in direct contact, a casting is used which holds the cable about 4 in. in front of the post. The claim is made that this arrangement adds a measure of safety, as vehicles will be less likely to hit the post.

Curbs.—Curbs at the edges of the roadway on bridges are being increased in height as a safety measure and as a protection to the bridge structure. Curbs 9 to 12 in. in height are used. Some states use even higher curbs and batter the face so that the vehicle hub



Device for Offsetting Cable Wires from Supporting Posts

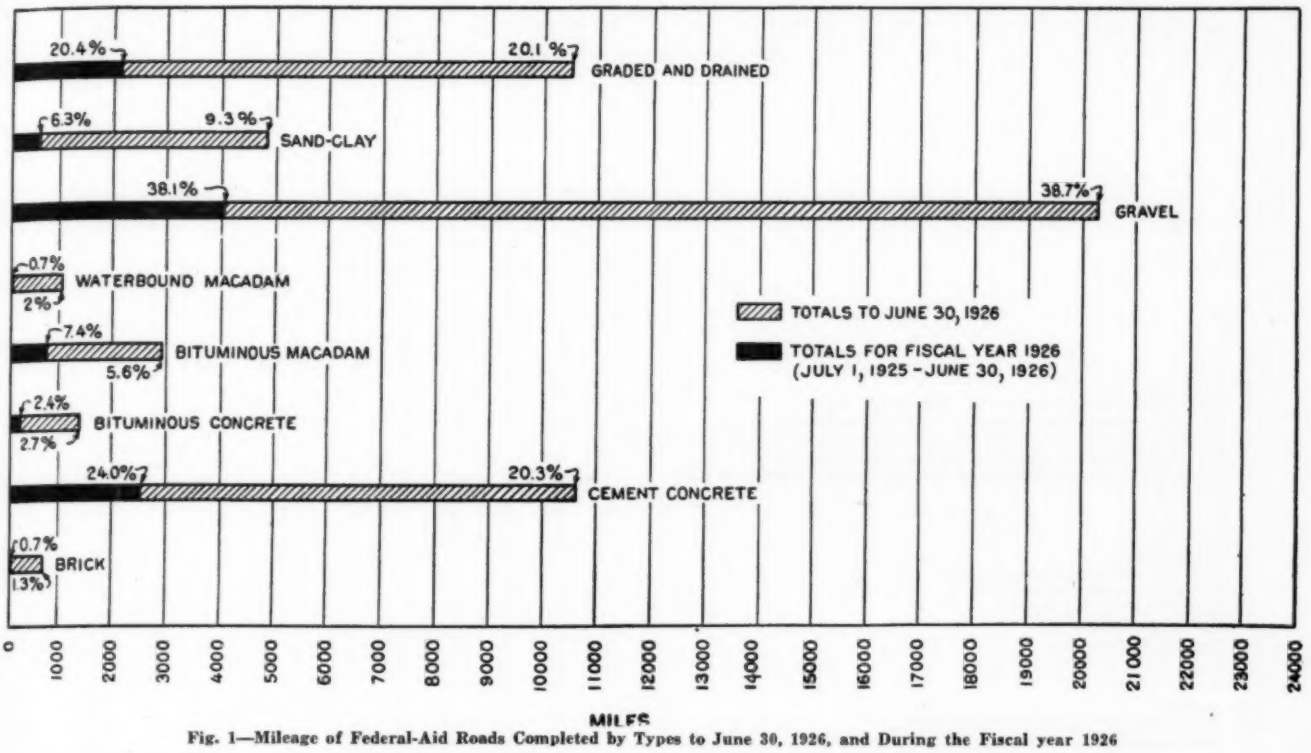


Fig. 1—Mileage of Federal-Aid Roads Completed by Types to June 30, 1926, and During the Fiscal year 1926

will not scrape. Several bridge failures have occurred as a result of vehicles colliding with a main bridge member, and signs of collisions are so common on bridges as to indicate the necessity of protection.

Shoulders.—There is a decided trend toward wider shoulders on rural highways. On any main route the entire surface is needed to accommodate moving traffic. Even where traffic is light a vehicle parked in any portion of a surface designed to accommodate two lanes of traffic constitutes an element of danger, and if such parking is on a location with restricted sight distance the danger is a most serious one. The stopping of vehicles on account of breakdowns and other reasons is unavoidable and wider shoulders to accommodate such cases are justified. The greater width of graded roadway will permit surface widening on a consolidated foundation when required. At least 80 per cent of the current plans provide for shoulders more than 4 ft. in width. Most of them provide for 5 ft., and a few require 6 ft. or more.

Grade Crossing Elimination. — The railroad grade crossings are recognized as one of the most important factors in the highway problem, and the public is thoroughly aroused to the necessity for reducing this danger. It is recognized that all crossings cannot be eliminated immediately and that an annual program must be worked out, abolishing the crossings in the order of their relative danger and taking into consideration the volume of rail and highway traffic.

During the past year 414 grade crossings have been eliminated on Federal-aid projects, making a total of 1,794 since Federal-aid work started. This is about 34 per cent of the grade crossings encountered. Of the crossings eliminated 1,076 were by relocation and the balance by means of overpass or underpass. Of the crossings eliminated during 1926, 202 were by relocation of the highway.

Road Types.—Figures 1 and 2 show graphically the trend of type selection on Federal-aid projects. The data are shown by Federal fiscal years ending June 30 of the designated year. The figures would not be materially different had calendar years been used instead of fiscal years. Fig. 1 shows the total mileage of the various types of completed Federal-aid projects, and also

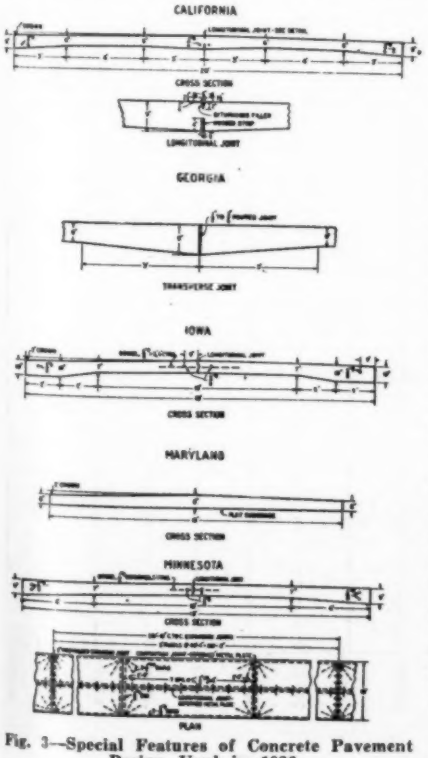


Fig. 3—Special Features of Concrete Pavement Design Used in 1926

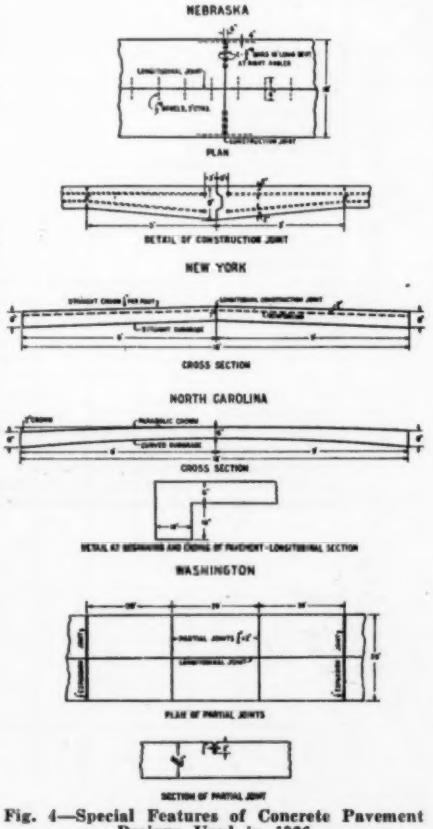


Fig. 4—Special Features of Concrete Pavement Designs Used in 1926

the mileage completed during the fiscal year 1926. Gravel easily predominates with 38.7 per cent of the total, and cement concrete is second with 20.3 per cent. These two types also predominated in 1926 with almost the same ratios, namely, gravel 38 per cent and cement concrete 24 per cent. Sand-clay mileage is 9.3 per cent of the total but only 6.3 per cent of the 1926 mileage, indicating that this type is not holding its former popularity. The mileage of this type has been steadily decreasing on Federal-aid work since 1922, and for new work is now practically confined to Alabama, Georgia, and South Carolina. Waterbound macadam also shows a decreasing popularity, being 2 per cent of the grand total and only 0.7 per cent of the 1926 mileage; but bituminous macadam forms a larger percentage of the 1926 work than of the total mileage. Bituminous concrete maintains approximately the same position in the 1926 work that it occupies in the total mileage, but brick dropped considerably. Comparison of the mileage completed each year since 1920 is shown in Fig. 2.

Concrete Pavement Design. — Since the use of Portland cement concrete for pavement surfaces is a comparatively recent development, it is natural that more changes are to be found in the design of this type of pavement than in other types. Tables I and II summarize the general practice in 1926. The most

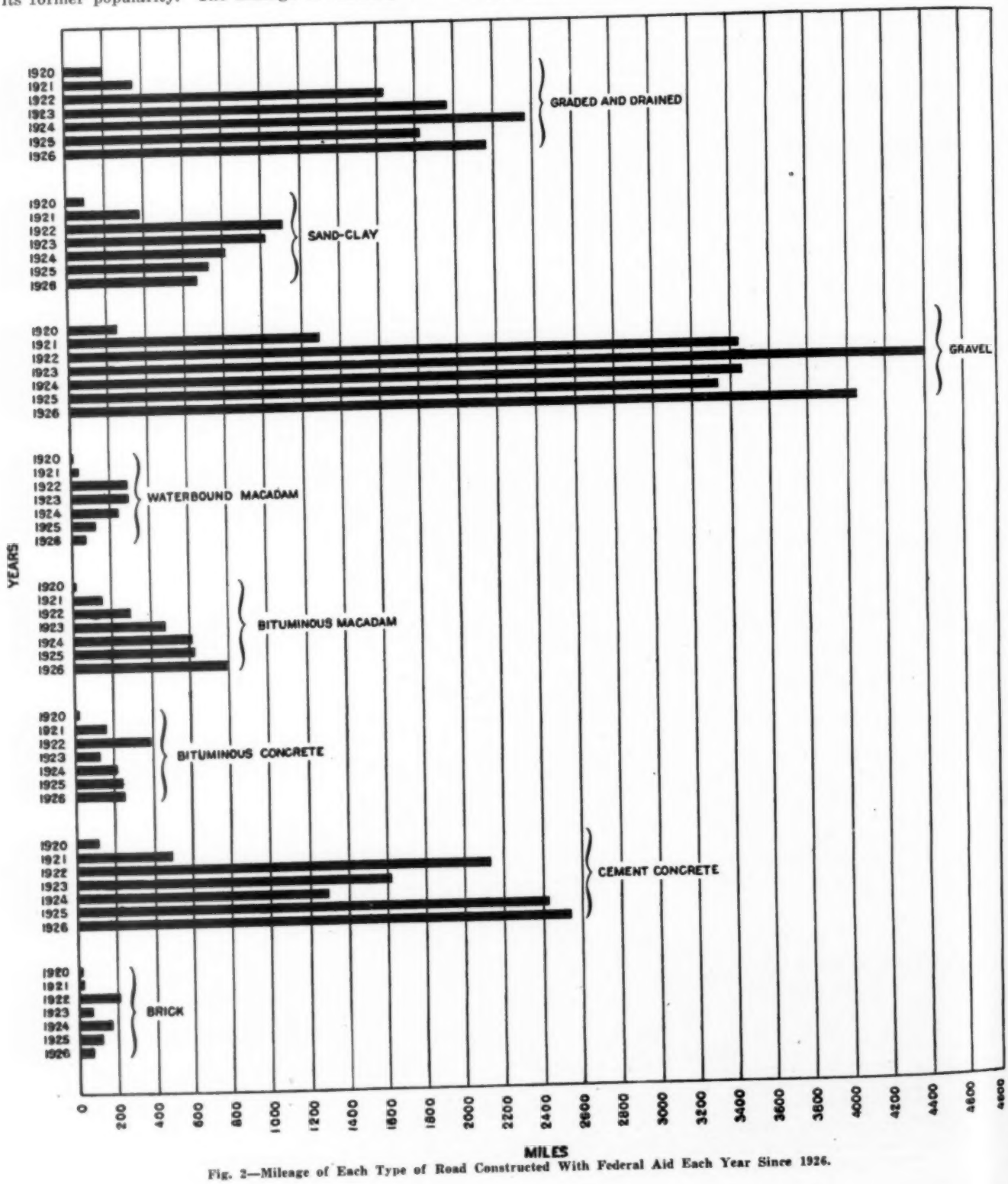


Fig. 2—Mileage of Each Type of Road Constructed With Federal Aid Each Year Since 1926.

important change is in the shape of the cross section. Prior to the season of 1921 all Federal-aid concrete projects provided for pavements of uniform thickness or of less depth at the edges than at the center. In 1921 the state highway department of Arizona submitted three projects involving the unique idea of constructing concrete pavements with the edges thicker than the center. During 1921 and 1922 the Pittsburg and Bates test roads were constructed and the results of the tests were widely published, with the result that in 1922 over 5 per cent of the concrete pavement designs for Federal-aid projects were of the thickened-edge type. In considerable effect in producing these variations. A study of the designs submitted to the bureau during 1926 shows that in 15 states the increase in thickness is made in the outer 2 ft. of the pavement, while in 10 states the increase is made in the outer 3 ft. In four states the transition is made in the outer 4 ft. Six states obtain the thickened edge by using a curved subgrade and a surface crown of longer radius, and one state uses a two-plane subgrade so that the increase in depth is at a uniform rate from the center to the edges.

Next in importance to the general adoption of the thickened-edge design also require dowels across the longitudinal joint but there is no general agreement as to whether or not these dowels should be bonded. In some states deformed bars are used to insure a bond and in others precautions are taken to prevent bonding.

The question as to whether or not expansion joints are required in concrete pavements is being given considerable study, as is the question of their proper spacing. The majority of states are using expansion joints at more or less regular intervals but a considerable number of states do not consider them necessary. As yet no general agreement has been reached among the states

Table I—General Features of Design of Cross Section of Concrete Pavements on Federal-Aid Projects Submitted in 1926

State[1]	Pavement cross section						Mix proportions	Reinforced type				Plain type
	Width	Thickness		Thickened-edge width	Crown			Bars	Mesh	Location	Edge bars	
		Edge	Center	Edge								
	Feet	*Inches*	*Inches*	*Inches*	*Feet*			*Lbs. per 100 sq. ft.*	*Lbs. per 100 sq. ft.*			
Alabama	18	9	6	9	3	2-inch, curved	1 : 2 : 3					No steel.
Arizona	18	9	6	9	2	1½-inch, curved	1 : 2 : 3½					Dowels only.
Arkansas	18	9	6	9	2	2¼-inch, curved	1 : 2 : 3½					Two ¾-inch diameter smooth edge bars.
California	20	9	6-9-6	9	3	1-inch, curved	1 : 2 : 4 (approximate)					Four ¾-inch diameter deformed edge bars.
Colorado	18	9	6½	9	3	1¾-inch, parabolic	1 : 2 : 3					Dowels only.
Connecticut	18 to 20	8	8	8		2½-inch, circular	1 : 1¾ : 3¼ or 1 : 2 : 3½	55 to 63		Top or bottom		
Delaware	18	8	6	8	Circular	2-inch, circular	1 : 2 : 4[2]					Do.
Florida	18	9	6	9	3	2¾-inch, curved	1 : 2 : 4 or 1 : 2 : 3½		40	2 inches from top		Do.
Georgia	18	9	6	9	3	1½-inch, curved	1 : 2 : 3½		44	do		No steel.
Idaho	18	8	6	8	2	1-inch, curved	1 : 2 : 3					Dowels only.
Illinois	18	9	6	9	3	2-inch, circular	1 : 2 : 3½					Two ¾-inch diameter smooth edge bars, painted or oiled.
Indiana	18	9	7	9	2½	2-inch, curved	1 : 2 : 3					Do.
Iowa	18	10	7	10	2	2-inch, curved	1 : 1¾ : 3 to 1 : 2 : 3½					Four ¾-inch diameter edge bars.
Kansas	18	9	6	9	4	2-inch, parabolic	1 : 2 : 3½					Four ¾-inch diameter smooth edge bars.
Kentucky	16	9	6	9	2	2-inch, curved	1 : 2 : 3½	42 (alternate types)	40 (alternate types)	2 inches from top		Two ¾-inch diameter smooth edge bars painted or oiled.
Louisiana	20	9	6	9	2	2¾-inch, curved	1 : 2 : 3½		58	do		
Maine	20	9	7	9	4	1¾-inch, curved	1 : 2 : 3½	91		5 inches from top		
Maryland	15	6	6	6		2-inch, circular	1 : 2 : 4 (approximate)		22 to 25	2 inches from top		No steel
Massachusetts	20	8	8	8		2¾-inch, circular	1 : 2 : 4[3]	95		2 inches from bottom		
Michigan	20	9	7	9	3	2-inch, curved	1 : 2 : 3½	90 (alternate types)	55 (alternate types)	3½ inches from top		Dowels only.
Minnesota	18	9	7	9	4	1-inch, curved	1 : 2 : 3½					Six ¾-inch diameter edge bars.
Mississippi	18	9	6	9	2	2-inch, circular	1 : 2 : 3					Two ¾-inch diameter smooth edge bars.
Missouri	18	9	6	9	2	1¼-inch, curved	1 : 1¾ : 3 to 1 : 2 : 3½					Two ¾-inch diameter smooth edge bars, painted or oiled.
Nebraska	18	9	6	9	3	1¼-inch, curved	1 : 1¾ : 3					Corner bars, ¾-inch diameter.
New Hampshire	18	9	6	9	2	2-inch, curved	1 : 2 : 3 (approximate)		66	2 inches from top		
New Jersey	20	8	8	8		2-inch, parabolic	1 : 1¾ : 3½ to 1 : 1½ : 3	28 to 80 (alternate types).	26.4 to 72.2 (alternates types).	Top and bottom		
New Mexico	18	9	6	9	2	1¼-inch, parabolic	1 : 2 : 3 (approximate)		25	2 inches from top		No steel.
New York	18	7	6	7	9	1½-inch, straight	1 : 1½ : 3	80 (alternate types)	46 (alternate types)	do	4½-inch diameter	
North Carolina	16 to 18	6 / 8	6	6 / 8	None. Parabolic.	2-inch, parabolic	1 : 1½ : 3 to 1 : 2 : 4	72 to 74	63 to 65	3½ inches from top	4¾-inch diameter.	Dowels only.
North Dakota	20	9	6	9	3	3½-inch, circular	1 : 2 : 3½	47		2½ inches from bottom		
Ohio	18	9	7	9	2	1¾-inch, curved	1 : 2 : 3	As shown	56 (alternate types)	2 inches from top		Two ¾-inch diameter smooth edge bars, painted or oiled.
Oklahoma	18	9	6	9	2	2-inch, curved	1 : 2 : 3½	32		4 inches from top		Dowels only.
Oregon	20	9	7	9	3	1½-inch, curved	1 : 2 : 3 (approximate)					Do.
Pennsylvania	20	8	6	8	Curved.	2-inch, circular	1 : 2 : 3 (approximate)	32 to 43		2 inches from top		
Rhode Island	18	8	8	8		2-inch, curved	1 : 2 : 3 (approximate)		42	do		
South Carolina	18	8	6½	8	Parabolic.	2-inch, parabolic	1 : 2 : 4		25	do		No steel.
Tennessee	20	8	6	8	Curved.	1¾-inch, parabolic	1 : 2 : 3½		44	As shown		Dowels only.
Texas	18	9	6	9	2	1½ to 2¾ inch, curved	1 : 2 : 3½	As shown on plans.		2 inches from top		Do.
Utah	18	9	6	9	2	1-inch, curved	1 : 2 : 3 (approximate)	do	As shown on plans.	As shown on plans		Two ¾-inch square edge bars.
Vermont	18	7	7	7		2-inch, curved	1 : 2 : 4	40½		Top and bottom		
Virginia	18	8	6	8	Curved.	2¼-inch, curved	1 : 2 : 4 (approximate)					No steel.
Washington	20	9	6½	9	2	1¼-inch, curved	1 : 2 : 3					Dowels only.
West Virginia	18	7	7	7		2¾-inch, parabolic	1 : 1¾ : 3¼ to 1 : 2 : 3½					No steel.
Wisconsin	20	9	6½	9	4	1-inch, curved.[2]	1 : 2 : 4 (approximate)					Dowels only.

[1] Four States, Montana, Nevada, South Dakota, and Wyoming submitted insufficient mileage to justify inclusion in the table.
[2] Admixture of 0.1 cubic foot of hydrated lime per bag of cement.
[3] Admixture of 0.06 cubic foot of hydrated lime per bag of cement.
[4] Unreinforced section.
[5] Reinforced section.

1923 the percentage of thickened-edge designs increased to 46 per cent, in 1924 to 73 per cent, in 1925 to 80 per cent, and in 1926 to 81 per cent. In mileage of roads the percentage of the thickened-edge type would be much greater because the uniform-thickness and thin-edge designs are mostly on short projects.

While the thickened-edge section has been almost unanimously accepted in principle by the state highway departments, there is still a notable lack of uniformity in the dimensions of the section used in various states which cannot be wholly accounted for by varying requirements of loading and subgrade conditions. The difficulty encountered in properly shaping and consolidating the subgrade has had is the adoption of the longitudinal center joint in concrete pavements by a large majority of the state highway departments. Thirty-four states now definitely require a longitudinal joint and it is expected that the coming season will show an increase in this practice. The longitudinal joint, in addition to effectually preventing irregular and unsightly longitudinal cracking, acts as a permanent traffic line and permits of half-width construction. A number of states now require that the pavement be constructed one-half at a time in order to avoid detouring traffic during the construction and curing period. In most cases the joint is formed by a deformed plate of 16 or 18-gauge metal which produces a tongue-and-groove connection. A majority of the states using expansion joints as to their proper spacing and width, or the necessity of dowels across the joint. There does, however, seem to be a general agreement that when dowels are used, provision should be made for free movements of the concrete by preventing the bonding of both ends of the dowels.

Little change is noted in the proportions of cement to total aggregate in the pavement mixtures but there is a growing tendency to vary the proportions of fine to coarse aggregates to produce dense concrete. Considerable emphasis is being placed on the amount of water used in the mix and relatively dry mixes are now the rule rather than the exception. Admixtures do not appear to be gaining in popularity since only two states use an admixture as a

standard requirement. The use of special cement or special methods of manipulation to obtain high early strength is coming into use for emergency work, particularly in the construction of bridge floors, but does not appear to be considered for ordinary concrete pavement construction because of the large increase in cost. In general, the mixtures specified for concrete pavements range from 1:2:3 to 1:2:4, although certain states specify a cement-sand ratio of 1:1½ or 1:1¾ for special aggregates.

was made to eliminate, so far as possible, such designs as appeared to be unusual and to select the one most representative of the usual practice in each state. Certain states have developed standard designs which are apparently used without variation, while other states vary such features as depth of pavement, mix, amount and position of steel reinforcement, spacing of transverse joints or the shape of the cross section, to fit local conditions. In four states so few projects involving concrete pavements have been received that

Bituminous Macadam.—In the construction of bituminous penetration macadam there has been a notable trend toward the use of stiffer binder. As an illustration of this change, the penetration test requirements in Ohio have been reduced from a range of 90 to 120 in 1923 to 85 to 100 in 1926, and in North Carolina 90 to 120 in 1922 to 80 to 100 in 1926, and in New York from 120 to 150 in 1923 to 100 to 120 in 1926. There is also a tendency, in this type of construction, to use larger and more uniform sizes of crushed stone and to

Table II—General Features of Design of Joints in Concrete Pavement on Federal-Aid Projects Submitted in 1926

State [1]	Longitudinal joint		Transverse joint				Dowels		Special features
	Type	Gauge or width	Type	Spacing	Width	Filler	Longitudinal joints	Transverse joints	
				Feet	*Inches*				
Alabama	Not required		Expansion	40	½	Prepared bituminous		None	
Arizona	As shown on plans		do	40	½	do	½-inch diameter, 5 feet c. to c.	do	
Arkansas	do		do	50	½	Prepared or poured bituminous.	4 feet by ½-inch diameter, deformed, 5 feet. c. to c.	Two, 4 feet by ½-inch diameter	
California	Submerged. (See fig. 3).		do	50	½ to ¾	do	None	Ten, 2 feet by ¾-inch diameter, smooth, one end free.	See Figure 3 for longitudinal joint and cross section.
Colorado	Deformed metal plate	18	do	60	½	Prepared bituminous	4 feet by ½-inch diameter, smooth, 5 feet c. to c.	None	
Connecticut	Prepared or poured bituminous.	½-in.	do	40	½	Prepared or poured bituminous.	None	do	Reinforcing in top on cuts, in bottom on fills.
Delaware	Deformed metal plate	16	Construction	(2)			4 feet by ½-inch diameter, deformed, 5 feet c. to c.	Seven, 4 feet by ½-inch diameter, smooth, one end free.	Admixture of hydrated lime.
Florida	Not required		Expansion	40	¾ to ½	Prepared or poured bituminous.		Size and spacing not shown, one end free.	
Georgia	do		do	(3)	½ to ¾	Poured bituminous		None	See Figure 3 for thickened transverse joint.
Idaho	Deformed metal plate	14	do	30	¾ to ½	Prepared bituminous	2 feet by ½-inch diameter, 21 inches c. to c.	do	
Illinois	do	16	Construction	(2)			4 feet by ½-inch diameter, deformed, 5 feet c. to c.	do	
Indiana	do	16	do	(2)			4 feet by ½-inch diameter, deformed, 5 feet c. to c.	Six, 4 feet by ¾-inch diameter, smooth, one end free.	
Iowa	do	18	do	(2)			5 feet by ½-inch diameter, 4 feet c. to c.	Nine, 2 feet by ½-inch diameter, smooth, one end free.	See Figure 3.
Kansas	do	18	Expansion	150	¾	Prepared bituminous	4 feet by ½-inch diameter, deformed, 5 feet c. to c.	None	Tongue and groove construction joint.
Kentucky	do	16	do	30	½	do	do	do	
Louisiana	do	16	do	30	½	Prepared or poured bituminous.	do	Seven, 4 feet by ½-inch diameter, smooth, one end free.	Half-width construction required.
Maine	Poured bituminous filler	(4)	do	60	½	Prepared bituminous	2 feet by ½-inch diameter, smooth, 3½ feet c. to c., one end free.	Eight, 2 feet by ½-inch diameter, smooth, one end free.	Do.
Maryland	Not required		Construction	(2)				None	See Figure 3.
Massachusetts	Poured bituminous filler	(4)	Expansion	60	½	Poured bituminous	3½ feet by ½-inch square, deformed, 5 feet c. to c.	Eight, 4 feet by ½-inch square, smooth, one end free.	Half-width construction and admixture.
Michigan	Deformed metal plate	16	do	75 to 100	1	Prepared bituminous	5 feet by ½-inch diameter, 5 feet c. to c.	None	
Minnesota	do	16	do	201⅔	2	do	4 feet by ½-inch diameter, deformed, 5 feet c. to c.	Six, 2½ feet by ¾-inch diameter, smooth, one end free.	See Figure 3.
Mississippi	do	18	do	30	¾ to ½	Prepared or poured bituminous.	do	Ten, 4 feet by ¾ inch diameter, smooth, one end free.	
Missouri	do	16	Construction	(2)			do	None	
Nebraska	Deformed metal plate	18	do	(2)			4 feet by ½-inch diameter, 5 feet c. to c.	None	See Figure 4 for sketch of thickened, tongue and groove joint.
New Hampshire	Poured bituminous filler	(4)	Expansion	30	¾ to ¾	Prepared or poured bituminous.	None	Eight, 2 feet by ¾-inch diameter, smooth, one end free.	Half-width construction required.
New Jersey	Prepared bituminous filler.	½-in.	do	34½ to 43½	½	do	None	Nineteen, ¾-inch diameter, smooth, one end free.	Double line of reinforcing.
New Mexico	As shown on plans		do	30	¾ to ½	Prepared bituminous	When shown	None	
New York	Plain butt joint		do	40	½	do	None	None	Half-width construction, see Figure 4.
North Carolina	Not required		Construction	(2)				Eight or nine, 4 feet by ¾-inch diameter, one end free.	See sketch of drop curbs at pavement ends, Figure 4. Heavy crown.
North Dakota	Deformed metal plate	(4)	Expansion	30	½	do	5 feet by ½-inch diameter		
Ohio	do	18	Construction	(2)			5 feet by ½-inch diameter, deformed		
Oklahoma	do	18	Expansion	50	1	Poured bituminous	4 feet by ½-inch diameter, 5 feet c. to c.	None	
Oregon	do	18	do	25	¾	Prepared bituminous	3 feet by ½-inch square, deformed, 3 feet c. to c.	None	
Pennsylvania	do	14	do	(2)	½	do	4 feet by ½-inch diameter, deformed, 5 feet c. to c.	None	Expansion joint location predetermined.
Rhode Island	Plain butt joint		do	100	½	do	2 feet by ½-inch square, 3 feet c. to c.	Eight, 2 feet by ½-inch diameter, smooth, one end free.	
South Carolina	Not required		do	40	¾ to ¼	do		None	
Tennessee	Deformed metal plate	18	do	30	¾	Prepared or poured bituminous.	4 feet by ½-inch diameter, 5 feet c. to c.	None	
Texas	do	18	do	60 to 100	¾ to ½	do	4 feet by ½-inch diameter, 3½ to 5 feet c. to c.	Six, 4 feet or 5 feet by ½ or ¾-inch diameter, smooth, one end free.	
Utah	do	18	do	40	¾ to ½	do	4 feet by ½-inch square, 5 feet c. to c.	None	Tongue and groove construction joint.
Vermont	Poured bituminous filler	(4)	do	43½	½	do	2 feet by ¾-inch diameter, deformed, 3½ feet c. to c.	Eight, 2 feet by ¾-inch diameter, smooth, one end free.	
Virginia	Not required		Construction	(2)				None	
Washington	Poured bituminous filler	½-in.	Expansion	60	¾ to ½	Poured bituminous	2 feet by ½-inch square, smooth, 1½ feet c. to c.	None	See Figure 4 for sketch of construction joint.
West Virginia	Deformed metal plate	16	Construction	(2)			None	None	
Wisconsin	do	18	Expansion	31½	½	Prepared bituminous	4 feet by ½-inch diameter, deformed, 4 feet c. to c.	Four, 4 feet by ¾-inch diameter, one end free.	

[1] Four States, Montana, Nevada, South Dakota, and Wyoming, submitted insufficient mileage to justify inclusion in the table. [2] Paint coat. [3] Not shown. [4] Necessary. [5] Designed.

Less steel per square yard of pavement is now used as reinforcement than formerly, although the total amount of steel used, including edge bars, dowels, and metal joints is probably greater. Only seven states, six of which are located in the northern part of the country where the soil freezes to considerable depth, specify bar mats in preference to fabric reinforcement. The majority of states using a reinforced design specify fabric or permit either fabric or bar types to be used.

Figures 3 and 4 show sketches of some unique and interesting features of design found in certain states. In compiling the data for Tables I and II effort no general idea of their practice in designing could be obtained.

Sand-Clay and Gravel Surfacing.—There does not seem to be any material change in recent years in the technic of constructing sand-clay roads, but the tendency in clay-bound gravel construction is toward the use of smaller sizes of gravel in the surface course. Experience in maintaining gravel roads under automobile traffic has shown that gravel larger than 1 in. in size is loosened and "kicked out" of the surface and any considerable amount of large gravel is likely to result in failure of the surface by ravelling.

reduce the depth of the top course from the 3 and 3½ in. formerly used to 2 and 2½ in.

The reduction in the depth of the course and the use of larger and more uniform sizes of stone permits more complete and uniform penetration of the course, and, together with the stiffer asphalt, tends to eliminate the development of corrugations in the surface under heavy traffic.

Protection of the edges of bituminous macadam by an extension of the base course has been adopted to a limited extent and this feature is standard design in Ohio.

Bituminous Concrete.—The effect of

A California Road, Originally a 24-Ft. Bituminous Concrete on a Concrete Base Widened to 42 Ft. by the Addition of Concrete Shoulders and a New Asphalt Concrete Surface Applied

research and wider experience in the construction and maintenance of bituminous concrete pavements is shown in the tendency toward more rigid requirements in grading the mineral aggregates. The practice of constructing this type of surfacing on a rigid base of Portland cement concrete appears to be gaining in favor, due to the difficulty in properly consolidating new macadam bases and also to the small differential in the cost of construction.

Brick.—Until rather recently grout-filled brick on a sand cushion and monolithic brick pavements were standard construction, but these types are now practically obsolete. All of the Federal-aid brick pavement projects submitted for several years have provided for the use of a bituminous joint filler. The practice of laying bricks flat rather than on edge is now so commonly adopted as to be accepted as standard construction.

Recent test results indicate that brick as thin as 2½ in. may be used for paving. The report on these tests* has been issued only recently and it is anticipated that the results will be reflected in designs submitted in the future.

Methods of Reconstruction.—The reconstruction of old pavements which have become badly worn or are of inadequate depth and width for present traffic is a problem of considerable magnitude in some of the states. In the majority of cases the old surfacing has considerable value and the method of reconstruction adopted should conserve this value as far as possible. The method of widening old, narrow macadam surfaces adopted by the State Roads Commission of Maryland has been used on a large mileage in the state. At the edges of the old macadam surface, concrete shoulders are constructed. These are generally 2 ft. in width and 8 in. in depth and are placed at an elevation

Half-Width Construction of Concrete Pavement Avoids Detouring During Construction.

Old Penetration Macadam in Maryland Reconstructed and Widened by the Addition of New Concrete Shoulders and New Penetration Macadam Top

which will permit resurfacing the existing macadam and at the same time eliminate the excessive crown found on many of the old roads. Resurfacing is done with either bituminous macadam or bituminous concrete. Excellent results are being obtained by this method at a moderate cost per mile. The same plan is being followed in other states and in some cases the side strips are made sufficiently wide to form traffic lanes. The resulting pavement is particularly pleasing to fast traffic because of the definite and ample separation of traffic.

Old concrete pavements have been successfully widened and resurfaced by constructing an additional layer of plain or reinforced concrete over the old pavement and extending the new slab beyond the edges of the old pavement.

*Thin Brick Pavements Studied, Public Roads, vol. 7, No. 7, September, 1926.

In such cases the new portion of the pavement is usually not less than 5 in. in depth at the center and thickened at the edges to equal the combined depth of old and new pavement. Contrary to expectation, such pavements have not shown any marked tendency to develop cracks along the edges of the old pavement or over cracks in the original surface. Old brick and bituminous pavements on concrete bases, as well as old macadam surfaces, have also been successfully resurfaced and widened by the same method.

Concrete roads have also been resurfaced with bituminous concrete, placing a first course which takes out the inequalities of the old surface and then the wearing course. Where additional width has been desired this has been secured in some cases by placing new concrete shoulders and in other cases by laying a strip of bituminous concrete base on each side of the old pavement and laying the surface course on both the new and the old construction.

Training Maintenance Men

How a State Highway Department Instructs Its Employees Described in New Mexico Highway Journal

By E. B. BAIL
Assistant Engineer, State Highway Department of New Mexico

The New Mexico Highway Department has established at Encino a department for the instruction of maintenance men.

Primarily the Highway Training School, as the new department is called, exists for the purpose of instructing new employees in their duties, but its scope will be widened to further train men who are already with the department in special phases of maintenance, such as operation of crushing plants and other special equipment.

Torrance County was decided upon as offering the most suitable location for the school. This county is centrally located with respect to the rest of the state and has within its confines practically every type of road and road material. The eastern part of the county has large deposits of caliche; the western half extends into the Manzano Mountains; here are clay roads with their attendant difficulties of maintenance and here are great gravel deposits for surfacing purposes. The southern half is preponderantly sandy.

During the winter months drifting snow is the largest factor to be dealt with; in the spring blow sand must be fought in the country around Mountainair. To sum up, every difficulty a maintenance department must face, is met in Torrance County and students will be trained to cope with all of them.

The school assumed working form when L. C. Tucker arrived at Encino Feb. 18th to take active charge. The state had previously acquired a machine shop and garage at Encino, and repairs were at once started on the patrol equipment in the district. Three 10-ton tractors with heavy graders, together with several F. W. D. trucks and necessary equipment, are being used by the student employees.

At present twenty-five men are in training. These men are from all sections of the state, Spanish-Americans predominating.

Under present practice the district engineers select the men they wish trained. The men bring their bed rolls and pay their transportation. They are furnished steel cots on arrival at the school. Bunk houses are provided and those who wish to do their own cooking are allowed the use of cook stoves for which they must themselves furnish the fuel. They are paid $2.50 per 9-hour day.

Ordinarily the district engineers advise the school superintendent what, in their opinion, the men they send are best qualified for; as truck driver, grader, runner, patrol foreman, etc.

However, all students are first introduced to the grader, this machine being an indispensable part of every patrol's equipment. They are thoroughly familiarized with the operation of the machine. At this stage of their instruction two or three students are assigned to each grader. After a week of this work in which time they have come to know the purely mechanical part of the operation they are taken singly and given a stated section of road to build, repair, or widen. Right at this point it will become apparent whether or not a man can be made into an efficient grader runner. A grader is an innocent looking affair and it would appear to the casual observer that nothing could be simpler than to operate one. But to operate one properly, to get a good job, one must have an "eye," as the expression is and not all men are so gifted. Men without the "eye" can be made into "so-so" runners, but the resulting product is not worth the expense.

Men unable to qualify as grader runners are tried out on trucks; if they cannot demonstrate ability to look after such equipment properly they are classed as common labor and released from the school.

For rating purposes the school classifies men who complete the training as truck drivers, tractor drivers, grader runners and patrol foremen. A good patrol foreman should be able to fill any of the above mentioned positions, except that he need not necessarily be an expert tractor driver, although he should understand tractor operation and know when he is getting results from this sort of machinery. In addition to being able to do the things enumerated above, the patrol foreman must be able to handle men and to get the most out of labor under his supervision. He must be energetic and ready and willing to get his crew onto the roads when weather conditions demand it, and he must be able to keep them there while favorable working conditions exist regardless of Sundays, holidays and regular working hours. Men of this type are hard to get; the school cannot insure that the men it turns out are of that type; a man may be able to perform all the mechanical operations efficiently and yet fail in the test of actual maintenance because he lacks that essential requirement which may be briefly described as "guts."

No definite period has as yet been settled upon as being the minimum time in which a student can be trained; naturally the time required will depend on the individual. It is believed that thirty days should be the shortest time given a student. It is felt that if a man show sufficient interest in the work to pay his transportation to the school and put in nine hours a day for the small wage paid he is entitled at the least to a fair try out, and if he evidences a willingness to work after he gets there he should have at least thirty days to demonstrate his ability.

It is believed that, to get the maximum of individual instruction the school should not have under training more than thirty men at any one time, as this number represents about all that can be handled on the equipment required to carry on the regular maintenance work of a district the size of Torrance County.

Men who display a more than usual aptitude for handling equipment will be selected for training as tractor drivers, for these heavy machines require a closer supervision and a more intelligent class of operators than are apt to be found on the average patrol.

Repairs to equipment required for the school are handled in Encino Shop, which is being equipped to handle promptly all types of trucks and tractors in use in the state.

Forest Road Fund Apportioned

Apportionment of the $4,500,000 forest highway fund for the year beginning July 1 has been announced by Secretary Jardine as follows: Alaska, $361,500; Arizona, $243,500; California, $575,000; Colorado, $312,000; Idaho, $462,500; Minnesota, $36,800; Montana, $361,000; Nebraska, $4,595; Nevada, $83,887; New Mexico, $186,000; Oregon, $533,000; South Dakota, $33,600; Utah, $164,600; Washington, $415,000, and Wyoming, $200,000.

The money will be expended for highways in or adjacent to the national forests, in accordance with programs for the various states adopted at conferences between State Highway Commissioners and officials of the Forest Service and Bureau of Public Roads.

Preventive and Corrective Street Cleaning

Methods Applicable to Town of 5,000 and Larger Municipalities Outlined in March Public Management

By W. P. HUNTER
City Manager, Roanoke, Va.

Street cleaning should be placed under two general heads: preventive and corrective. The value of the first named —preventive—cannot be expressed in dollars or reduced to square yards cleaned, but the zeal and energy put into the work of preventive cleaning will soon show a marked decrease in cost and increase in yardage of corrective measures.

As many of you present have traveled throughout the towns of this country, have you not asked yourself the question, "Why is Town 'A' such a clean appearing place from its main thoroughfare to its outskirts, while Town 'B,' a town of the same size, and the same industries, generally speaking, is such an unsightly place?" If we could go back into the history of Town "A" we would doubtless find a cooperation between municipal authority and Mr. Private Citizen from which many of us could take lessons, and which did not exist in Town "B."

I imagine many of you present are now thinking of your "Clean-Up Week" and are ready to present many fine new points in your method. But how are you taking care of the remaining 51 weeks of the year to make your city approach the spotless town or city.

Now let us look into the various methods by which preventive cleaning may be carried on. I list them under the following headings: Newspaper publicity, literature in pamphlet and display form, m e e t i n g s, education through schools and other agencies, and the police.

The Newspaper Campaign.—First let us take up newspaper publicity. All local papers are boosters for the city, and will donate space for anything having to do with the welfare of the community. Obtain a good reporter, or someone who can write a series of short articles, giving the present conditions, existing examples of good and bad sections, how the citizen can cooperate, the aim of the street cleaning department, followed up with the equipment, organization, etc., then give from time to time results which have been attained. If possible such articles should appear always on the same page and in the same column, nor should they follow too closely, but should be far enough apart to extend over a year or more and yet keep the subject before the people. The power of thorough digestion of municipal facts by the average citizen is rather a slow process.

Another good method is through the medium of literature, by cards and pamphlets mailed or distributed. But such literature should be worded to fit the locality to which it is sent. Don't send a pamphlet telling how an industrial concern should care for its refuse, or its overloaded or leaky trucks and wagons, to a housewife.

Short, pithy sayings posted in street cars and buses and other public places, if well worded attract much attention. Stamps with catchy sentences used occasionally on your letters sent locally will reach many people who had not given the subject a thought. If the idea can be brought home to the individual citizen, that he can do more by preventive measures than the city street cleaning department can do by corrective measures, you will begin to get results which will attract attention.

Does the merchant or the citizen realize the importance of his cooperation with the city in keeping streets clean? I answer, they do not. If the merchant as well as the householder would collect all sweepings and put them into containers instead of sweeping the trash into the streets they would do much toward preventing an unsightly condition of streets.

The Part of Civic Organizations.—One can also accomplish much through meetings of various civic organizations, which are often anxious to be a real help to their communities, but often need guidance for the direction of their zeal. It would be well to secure good speakers before these bodies to present matters of cooperation and help. If you can present things in such a way to the average American citizen so that he feels he is doing something he thought of himself instead of being made to do it because it is the law, you will have a cooperation which will perhaps surprise many of you.

Make an appeal from the sanitary and health standpoints, as clean streets have a decidedly beneficial effect upon the public health of any municipality. The removal of debris, which may possibly be contaminated, is a necessary protection to public health. Of course, this should be done at a time and in such a manner as to reduce to a minimum the possibility of infecting the traveling public by means of dust. While this phase of street cleaning is a direct benefit to public health, the greatest benefit to public health is brought about by its indirect or psychological effect upon the public mind. Clean streets tend to improve the morale and increase the civic pride of the inhabitants of any city. Clean streets suggest clean yards, clean yards suggest clean houses, clean houses suggest clean bodies and clean living. Physical and moral cleanliness of the individual, and the observation of the rules of personal hygiene, will necessarily improve the public health of any municipality.

The educational heading is really a subhead of meetings, but I have more in mind this method carried out through the public schools. We all know only too well that much of our street litter comes through thoughtless children, and far be it from me to think we can change the nature of a boy to want to break up and throw away all he can get his hands upon, but much can be done by presenting this subject to him as a police duty, or something he must keep the other fellow from doing. Give him this viewpoint and you will do much to minimize this source of trash upon the streets.

Enlistment of Police Department.—Lastly, but one of the most important, is the enlistment of the police department, and your inspectors, also your foremen. Let them know that they, by courteous suggestions to the public, and the reporting of the most flagrant violations to the proper authority, are performing their duty in a manner which calls for commendation, and at the same time are helping the street cleaning department. As a suggestion along this line, we have two police officers who are furnished cars and each day patrol the city, or what parts of it they can, and are on the lookout for things which they can often correct at once by stopping and speaking to the person: For instance, a coal truck overloaded passes them, turns a corner and scatters part of its load over the streets to be ground up and made a fine dust. They get the name of the company, notify the officials, and as a rule they are only too glad to correct the trouble. They pass a new building, find material blocking the gutter so that the first hard rain will wash much of it away. They instruct the builder how easy it is to put in a few boards under his material, providing a drain, thereby saving him material as well as keeping the street cleaner. I could cite you case after case in which they help. Imagine the results you would obtain if every patrolman on his beat was educated to give the same attention to these details.

Now many of you perhaps think some of the ideas to be fanatical and impractical, but I feel confident that as time goes on we will find more and more

attention given to preventive cleaning along the lines outlined. Everyone present remembers when expectoration on sidewalks and in trains was a most common practice. Was it not by similar methods that this practice became a thing of the past?

Each City Has Its Own Peculiar Needs.—There has been so much written and so many talks given on corrective street cleaning that I feel there is but little which you have not heard or could not get from the many books and articles on the subject. Data concerning costs and equipment either from the records of my own city of Roanoke, Virginia, or figures obtained from other cities can only be used as a general basis of comparison.

Each municipality has its own peculiar needs, certain types of paving, industrial conditions and weather conditions, so that the equipment and method in use in one city may be anything but efficient in another of the same size. Has it not been a failing among many of us that we have been too prone to do as some other city is doing, or to take the equipment and organization as we found it in coming to a city without going into the matter and by careful consideration finding what is the best to fit the peculiar need of our community.

As an example, I may state that in Roanoke where we will average several snows a season, it had been the custom to clean immediately all sidewalks, shoveling the snow into the gutters, then clear the streets for traffic with a tractor and scraper. Using this method we had no place to shove the snow and it became piled so high next to the gutter that no vehicle could get near the curb.

We have decided, and we think it a better plan in the future to clean but a portion of the walks, where they are of sufficient width, piling the snow on the outer edge, thereby leaving more room to work in more adequate traffic lanes. However, snow removal in our city does not present the great problem it does in northern cities as we usually have light snowfalls. I simply state this in passing to bring the point before you that old established customs in one place, or at any one time, may bear scrutiny and change.

Old Methods Still Efficient.—But then there are certain methods of cleaning which, while old, will always be in use. For instance the one-man push broom and two-wheel cart first put into use by Benjamin Franklin in Philadelphia as the first street cleaning in this country is still most efficient today in business districts and main thoroughfares. They can clean the places most needed and work in and around parked machines which with any other method is next to impossible.

The old horse drawn sweeper followed by gutter brooms and carts on rough paved streets such as cobble, granite and rough macadam is still in use and in some instances is more efficient than the motor pick-up sweeper. But in any sweeper that is to be followed by brooms it is important if done efficiently to coordinate the sweeping and the brooms, otherwise the one will be waiting on the other.

In Roanoke we have approximately 65 miles of paved streets, consisting of granite block, brick, concrete, sheet asphalt and penetration macadam. The majority of our business section is brick paved, which is swept each night by a motor pick-up sweeper and patroled in the daytime by four whitewings, which do much to keep a clean appearance in the business section, picking up paper and other trash which litters up the streets during the day.

The paved residential sections are swept twice a week, using a horse-drawn sweeper for the granite block paving and rough macadam streets and the motor pick-up sweeper for the smooth pavings. With the horse-drawn sweeper we average 80,000 sq. yd. for a 9-hour day, with an average cost of $0.69 per 1,000 sq. yd. With the motor pick-up sweeper we average 100,000 sq. yd. for a 9-hour day with an average cost of $0.31 per 1,000 sq. yd.

With asphaltic, brick and concrete pavements, motor flushings is an advantage in cleaning but it has its limitations in most communities.

Around our market, which covers several blocks, we clean with brooms and wagons once a day and flush once a week. Flushing, where the city owns its own water system and has a sufficient supply is most advantageous, but with our privately owned water works, it cannot be carried on to any great extent.

Disposal of Street Sweepings.—I feel that one of the best methods is to find a large storage place where it cannot be objectionable to the abutting property owner. Store the street refuse in large piles where after a few years it will be found to be most useful in improving park grounds.

It is a well known fact that most of our streets are in worse conditions in winter, but I feel that to a large extent it is due to the lack of foresight. For example we have had a week of such inclement weather we could not use our equipment to any advantage. How many of us make use of Uncle Sam's weather forecast and watch for a forecast of better weather so we can mobilize all our forces and if necessary increase our force to do the work while it is possible?

Highway to Connect Andorra to Spain.—Andorra, the almost inaccessible principality in the Pyrenees, north of Spain, will be opened to the outer world by means of the construction of a $3,000,000 modern highway that will replace the present mule paths. The area to be thus made accessible contains some 400 square miles, containing valuable resources.

Estimating Quantities of Materials in Concrete

The following simple and accurate method of determining the quantities of materials required for a unit volume of concrete of any mix is given in March Concrete Highways and Public Improvements: This method is based upon the fact, established by tests, that the volume of concrete produced by any combination of materials, so long as the concrete is plastic, is equal to the absolute volume of the aggregate plus the absolute volume of the cement plus the volume of water. The absolute volume of a loose material is the actual total volume of solid matter in all of the particles. This can be computed from the weight per unit volume and the specific gravity as follows:

$$\text{Absolute Volume} = \frac{\text{unit weight}}{\text{sp. gr.} \times \text{the unit weight of water}}$$

Example: Suppose we use a 1:2.2:3.6 mix and a water cement ratio of 7 gal. per sack. Figure 1 sack of cement equals 1 cu. ft., weighs 94 lb. with a specific gravity of 3.1. Fine aggregate weighs 110 lb. per cu. ft., coarse aggregate 100 lb. per cu. ft. and their specific gravity is about 2.65. The volume of concrete produced by the above mix is calculated as follows:

$$\text{Cement} = \frac{94}{3.1 \times 62\frac{1}{2}} = .49 \text{ cu. ft.}$$

$$\text{Fine Aggregate (F.A.)} = \frac{110 \times 2.2}{2.65 \times 62\frac{1}{2}} = 1.46 \text{ cu. ft.}$$

$$\text{Coarse Aggregate (C.A.)} = \frac{100 \times 3.6}{2.65 \times 62\frac{1}{2}} = 2.18 \text{ cu. ft.}$$

$$\text{Volume of Water} = \frac{7.0}{7.5} = .93 \text{ cu. ft.}$$

Total Volume of Concrete Produced, 5.06 cu. ft.

Quantities for 1 cu. yd. of concrete:

$$\text{Cement} = \frac{27}{5.06} = 5.34 \text{ sacks or } 1.33 \text{ bbl.}$$

$$\text{F. A.} = \frac{5.34 \times 2.2}{27} = .43 \text{ cu. yd.}$$

$$\text{C. A.} = \frac{5.34 \times 3.6}{27} = .71 \text{ cu. yd.}$$

For unusual materials such as blast furnace slag, special light weight aggregates, etc., the exact specific gravities should be used. It will be found that for the purpose of estimating quantities the average value—2.65, given above, will be sufficiently accurate for sand and gravel and the common varieties of crushed rock.

For very porous aggregates corrections should be made for the quantity of water absorbed; for the volume of concrete produced will be reduced directly by this amount. For very wet mixes a further correction may be required due to water lost in handling.

Toledo to Spend $2,500,000 for Repaving.—Bids were opened on March 14 in Toledo, Ohio, covering the repaving of 14 streets and several alleys. The total cost of the work to be done this year will be about $2,500,000. This one letting involves the expenditures of a half million dollars.

Experimental Concrete Pavement Sections In California

Twenty-one Different Pavement Designs With Respect to Steel Reinforcing and Transverse Joint Spacing Used in Road Described in California Highways

By A. D. GRIFFIN
Resident Engineer, Division VII, California State Highway Department

A new section of California state highway has just been completed on the Oxnard coast route in Ventura county, Division VII. The type of pavement placed is cement concrete, 20 feet in width, the contract including also roadway grading and drainage structures.

The five miles of pavement comprise the connection between Oxnard and the coast in the direction of Point Mugu. The entire section is on new location through highly productive bean and sugar beet land on almost a direct line, shorter by two miles than the existing county road. The flat grades and straight alignment, with no breaks in the continuity of the pavement, and the almost uniformly sandy soil subgrade, presented an ideal opportunity for the construction department to work out its experimental sections.

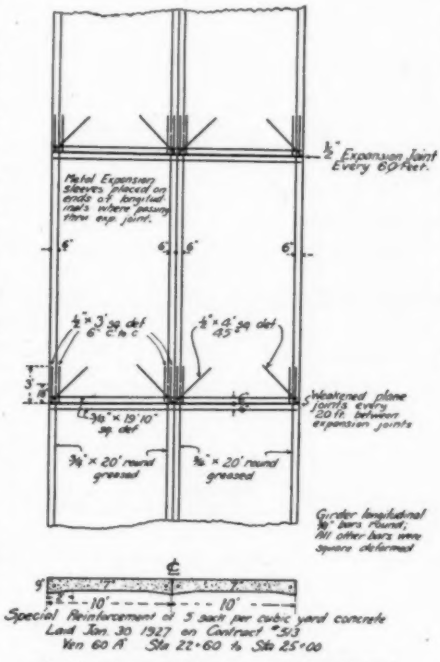
The contract provided for twenty-one different pavement designs with respect to steel reinforcing and transverse joint spacing. Unlike the test roads at Pittsburg, California, and Arlington, Virginia, the Oxnard pavement has been built for practical every day use on a route that is certain soon to have a heavy traffic at all seasons of the year.

It should be understood, however, that as far as the pavement as a whole is concerned there has been no radical departure from accepted practice; that the state's investment in high class concrete pavement has not been jeopardized.

Pavement Design.—The pavement design, as may be observed from the accompanying chart and construction detail sheet, changed every 1,200 ft., except for two longer sections at the beginning and end of the contract. Arrangement of the different sections is such that any effects due to possible variations in quality of the subgrade, or a heavier traffic in one direction than in the other, will balance one another, when the results for the entire five miles are combined and compared.

The center-line V-groove under which is placed a submerged wood strip and the transverse dowelled expansion joints, as used on this contract, are now standard California practice. The weakened plane transverse joints, to afford relief for tensile stresses by encouraging and localizing contraction cracking, are a new procedure, although a development of the same idea has been used by the City of Seattle. The concrete mix was all standard Class "A," six sacks of cement to the cubic yard, except for a short section which is subsequently described.

To guard against corner cracking where longitudinal edge and center bars were specified, the same type of reinforcing was carried transversely across the slab parallel to all expansion joints, except where slab reinforcement was used, when the precaution was considered unnecessary. A break in the longitudinal steel was always provided at all transverse expansion and weakened



Sketch Showing Location of Reinforcing and Joints

plane joints; no steel passed through the joints except the ¾ in. x 24 in. steel dowels. These were placed with slip-sleeves on one end to provide space for expansion. Ten dowels were used in each of the expansion joints, and four dowels in each of the weakened planes. In the latter instance the dowels were spaced 6 in. from the edges and center of the pavement. Dowels were held firm by wiring them to steel pins, ½ in. x 2 in., which were driven into the subgrade as supports. Placing of dowels was given particular attention throughout the project.

Contractor's Construction Program.—N. L. Basich and R. H. Richards, who represented the contractor, the United Concrete Pipe & Construction Co., appreciated the fact that the contract was unique in its variety of exacting requirements. They realized also the disadvantages of the usual method of hauling concrete paving materials and of conducting mixing operations on a subgrade composed of the prevailing sandy soil. Earth structures, 10 ft. in width, had been planned for either side of the 20-ft. pavement, which permitted two 5-sack mixers to be operated opposite each other, and entirely outside the pavement side forms.

Pneumatic-tired dump trucks delivered proportioned batches of rock and sand from the Saticoy Rock Company. All traffic was kept entirely off the subgrade, the hauling being done either along the shoulders or in the side ditches.

This arrangement made possible the lining up of pavement steel and transverse joints well in advance of the placing of the concrete. It also diminished confusion around the mixers and made for better progress. To further speed up operations, the contractor provided two Lakewood tampers which worked in conjunction with one another, except for short periods when repairs were necessary.

When weakened plane joints were being placed nine finishers were required to take care of a normal day's run. Adverse weather conditions prevented any record of exceptional progress on the job as a whole, but on many days over 400 cu. yd. of pavement were placed. This is better than 900 lin. ft.

Steel Reinforcement.—Three methods were used for the support of longitudinal steel bars in the pavement slab:

(1) ½ in x 12 in. steel pins which were driven into the subgrade and to which the longitudinal bars were wired;

(2) Movable braces, an invention of the contractor, which were taken out after the concrete had been spread and which were then reset;

(3) Stiff No. 8- or No. 10-gage wire supports, bent and welded with stop bars and hooks, which were driven into the subgrade and the headers and left permanently in place.

The last mentioned method proved by far the most satisfactory. The wire supports made possible setting of the reinforcing well in advance of placing of concrete. The bars were held firmly in place not only vertically and horizontally, but also longitudinally which is particularly important where breaks in the reinforcing steel must be accurately spaced for weakened plane transverse joints. The wire supports when left in place also insured against movement of the reinforcing steel during tamping operations. All other methods of steel support have obvious disadvantages.

When slab reinforcement was accomplished with wire mesh or ⅜ in. steel square deformed bars, the procedure was as follows:

A layer of concrete was struck off with a template at the depth at which the reinforcement was to go for the full distance between expansion joints.

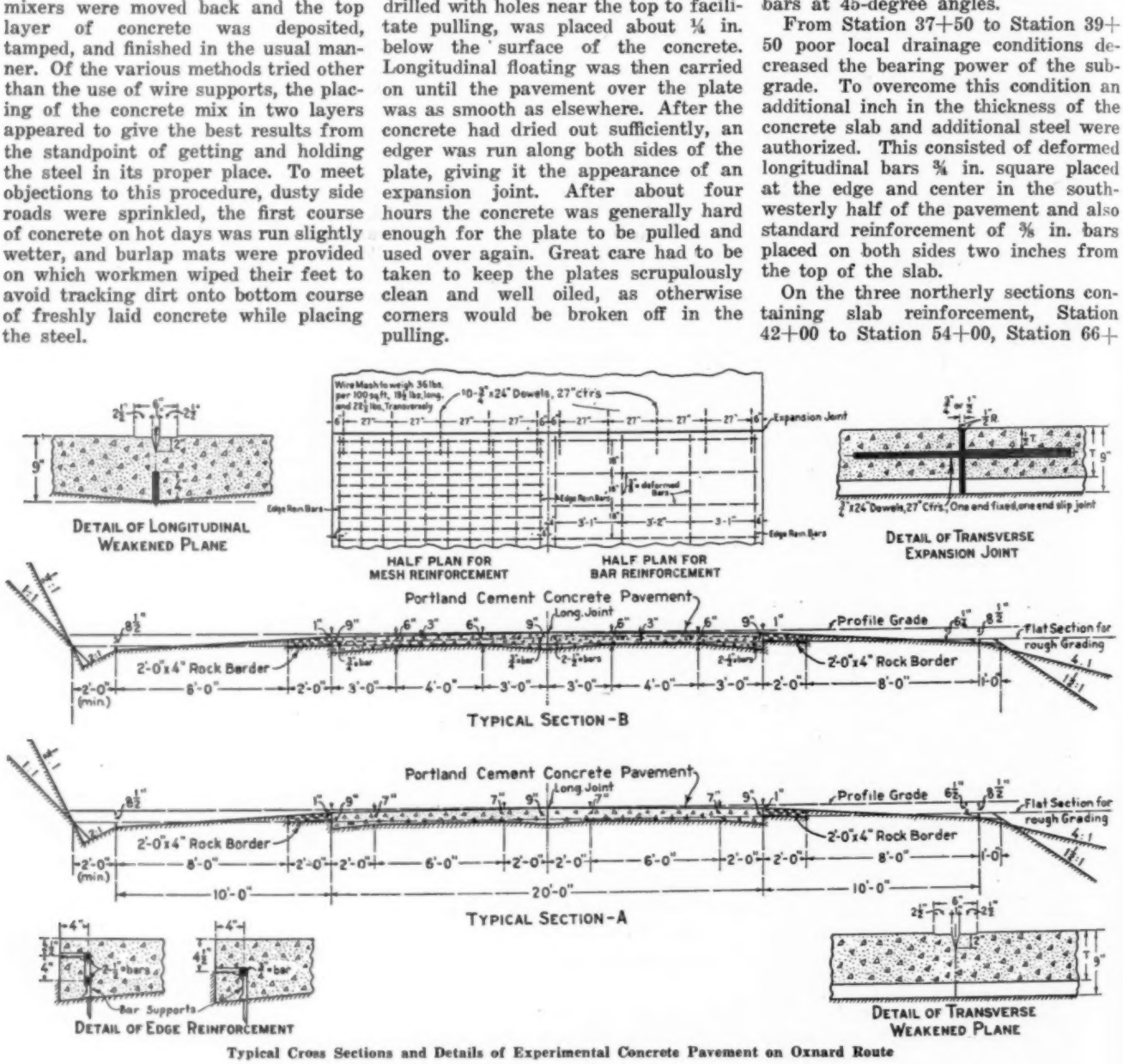
The wire mesh sheets or the previously made up mats of steel bars were then placed and wired to position. The mixers were moved back and the top layer of concrete was deposited, tamped, and finished in the usual manner. Of the various methods tried other than the use of wire supports, the placing of the concrete mix in two layers appeared to give the best results from the standpoint of getting and holding the steel in its proper place. To meet objections to this procedure, dusty side roads were sprinkled, the first course of concrete on hot days was run slightly wetter, and burlap mats were provided on which workmen wiped their feet to avoid tracking dirt onto bottom course of freshly laid concrete while placing the steel.

float had passed. In this groove a ¼ in. x 1½ in. x 19 ft. 10 in. steel plate, bent to roadway crown, tapered, and drilled with holes near the top to facilitate pulling, was placed about ¼ in. below the surface of the concrete. Longitudinal floating was then carried on until the pavement over the plate was as smooth as elsewhere. After the concrete had dried out sufficiently, an edger was run along both sides of the plate, giving it the appearance of an expansion joint. After about four hours the concrete was generally hard enough for the plate to be pulled and used over again. Great care had to be taken to keep the plates scrupulously clean and well oiled, as otherwise corners would be broken off in the pulling.

the two. This section should also prove or disprove the advisability of providing against corner breaking by placing bars at 45-degree angles.

From Station 37+50 to Station 39+50 poor local drainage conditions decreased the bearing power of the subgrade. To overcome this condition an additional inch in the thickness of the concrete slab and additional steel were authorized. This consisted of deformed longitudinal bars ¾ in. square placed at the edge and center in the southwesterly half of the pavement and also standard reinforcement of ⅝ in. bars placed on both sides two inches from the top of the slab.

On the three northerly sections containing slab reinforcement, Station 42+00 to Station 54+00, Station 66+



Typical Cross Sections and Details of Experimental Concrete Pavement on Oxnard Route

Weakened Plane Transverse Joints.—Considerable difficulty was experienced in the construction of transverse weakened plane joints. The special provision of the contract showed the transverse V-groove to be the same as the longitudinal center-line V-groove. An effort to follow this requirement indicated that the resulting transverse joint would not be smooth; a clean-cut V-groove by this method seemed impossible of construction without making an objectionable depression.

A method developed by Resident Engineer E. B. Brown, of Division V, for shoulder construction, was enlarged upon and was finally adopted for full width pavement. Under this plan the V-groove tamper was impressed in the concrete after the heavy longitudinal

Departures from Prescribed Designs.—Between Station 22+60 and Station 25+00, a part of typical section "A," the construction department directed that the concrete be poured five sacks to the cubic yard instead of six. Special reinforcement also was used as shown by the accompanying sketch. The ¾ in. smooth round longitudinal bars used on this section were greased in an effort to cause them to act as dowels over their entire length. Subsequent comparisons of this section with other sections which contain ¾ in. square deformed longitudinal bars, should determine whether or not the bonding of steel to concrete for the transference of tensile stresses is of as much importance as the dowelling action, in the absence of a bond between

00 to Station 78+00, and Station 90+00 to Station 102+00, the steel was placed 2 in. from the top instead of 3 in. as originally designed. This change was authorized because it was thought that, by being placed nearer the top, the reinforcement might be more effective in taking up tensile temperature stresses and the flexural stresses of heavy concentrated traffic loads. After the highway has been in use, comparison of these sections with the three where the steel is in the center of the slab should be of interest.

Because of high alkali content in the soil from Station 226+00 to Station 256+00, the completed subgrade was given two applications of asphaltic road oil to secure an insulating membrane under the pavement. The first appli-

cation was of oil with a 40 to 50 per cent asphaltic content, one quart to the square yard of subgrade; the second application was 80 to 90 per cent asphalt, in the same amount per yard. This oil treatment was also considered a protection against the shrinking and expansion of the subgrade; and, for this reason, a sand cushion between the subgrade and the pavement, which would otherwise have been placed on the northern half of this section, was eliminated. The soil was of an adobe nature having a linear shrinkage of from 5 to 8 per cent.

Station 199+00 to Station 210+00 was the first section constructed in which slab steel reinforcing was used. While building this unit the contractor was permitted to do some experimenting in the placing of the steel. For this reason the reinforcement on this section is more likely to be defectively placed than that used elsewhere on the project.

Except as above outlined, no other deviations were made in the original plans, nor do any further conditions come to mind which would seriously affect any conclusion which may be drawn from subsequent studies and comparisons of the various types of pavement design. As time goes on, it is hoped that these experiments may settle some of the moot questions regarding pavement design, steel reinforcement, and transverse joint spacing, which have not been as yet satisfactorily or conclusively answered.

Inspection parties who may go over this contract should have no trouble in picking up stations or in identifying the various sections, even without a copy of the layout plans. A different transverse joint spacing often marks a point of change in design. The contractor's stamp, placed at the beginning and the end of each day's run, also carries the station and the date. At points of change of design, the station number has been branded on either side of the expansion joint near the edge of the pavement.

There were also many visitors beside the state engineers. A. D. Griffin, as resident engineer, was in general charge for Division VII. The inspection work was done by the following assistant resident engineers: W. I. Templeton, T. A. Rosebury, E. W. Taylor, O. W. Monroe, B. T. Thomas and J. P. McAndrew.

M. I. T. Studies Subgrade Conditions

An important study of soils encountered throughout the country and their action when used as subgrade for highways is being carried on at the Massachusetts Institute of Technology, by Dr. Charles Terzaphi, co-operating with the Bureau of Public Roads. The program includes the development of standard soil tests and classifications, a laboratory study of soils, and the construction of several test roads for observation of soil behavior.

"Forgotten" Items in Estimating

From Public Construction News

One great mistake made by some contractors in estimating is that of forgetting or neglecting to include in their cost figures various items of expense which they are bound to have with every job. Every contractor has such expenses on every job, but some are so anxious to secure the work on which they are figuring that they carelessly or wilfully omit a number of these items. These items cost money and if not included in the estimated cost of the job greatly decrease or wipe out the anticipated profit.

Some of our readers know what we are referring to and we hope most of them include all these items in their cost estimates. The contractors that do include these items make money and are successful. The other fellows are the ones we want to reach.

Overhead Often Forgotten.—Among the items easily and often wilfully overlooked are those generally known as "overhead." In a contractor's overhead expense may be included such items as taxes, insurance of all kinds, surety bonds, interest value on investment, traveling expenses, allowances and bad accounts, the contractor's own time in looking after the work, time or salary of office help, automobile expenses, and many other big and little expense items, which, when added together, run up to a large percentage of the total work done by the contractor in a year.

Unless an expense account has been kept, we earnestly recommend that the contractor open one and charge to it every item of expense occurring during the season. To give an immediate illustration, total up the entire amount of your last year's work done and then go through your cash or check book and take off all overhead expense items. But do not include anything paid for materials, labor, etc. These must be charged separately to the job to which they belong.

Include Interest on Investment.—After all such expense items have been deducted, make an estimate of the amount of other items such as wear and tear on tools and equipment, renewal, expansion, interest on investment (Note: this item should be figured much higher than the rate a similar amount of money would return if invested in bonds or similar comparatively safe investment; contracting investments, records prove, are subject to more risks and should naturally earn more return —say at least 10 per cent), cost of figuring, securing and looking after work. There may be some other expenses which should be added to this list. Then, having included all these items, you are ready to figure your "overhead."

After the total amount of the overhead has been determined, by comparison with your last year's costs and your expectations for the coming season, you are ready to determine how much you will add to your cost estimate to provide for this expense which you must meet.

Three Ways to Include Overhead.—Three ways are open to you. You may determine the gross amount of business you expect to do during the coming season, find what gross you did last year, and the percentage your last season's overhead was of that gross business, and add to each estimate a sum sufficient to give you a similar percentage of the gross to pay your overhead. Or, a better way, perhaps, would be to figure your productive time from your records of the last year. This also serves as a check upon being too enthusiastic in estimating the length of time a given job will require. Divide the total overhead by the number of productive days, which gives the amount to be added to each estimated day per job. The third method is to determine what percentage of gross profit is required to pay overhead expenses and then add sufficient gross profit to each job figured to leave, after paying overhead expenses, a fair and moderate profit.

But above all, don't forget that overhead must be paid—either by the job or by taking money out of your own pocket.

Tourist Traffic in Missouri

In order that an estimate of the expenditures by tourists in Missouri in a year could be determined a number of questionnaires in the form of postcards were handed out to tourists, over the state during August and September, 1926. Approximately 2,100 of these cards were mailed in to the state highway department by the tourists.

The 2,108 cars reporting carried 7,201 passengers and stayed in the state 22,495 days. The total expenditures reported by the occupants of these 2,108 cars was $155,364. The total mileage of the cars in the state was 1,191,252.

The following is a summary of the replies:

Expenditure per car per trip	$73.70
Mileage per car per trip, average	565.1
No. gallons gas per car at 14 2-7 mile per gallon	39.5
Amount gas tax per car per trip	$ 0.79
Average No. days in Missouri per car	10.7
Average expenditure per day per car	$ 6.90
Average No. of passengers per car	3.4
Average expenditure per passenger	$21.50
Average number of miles per day per car	52.0

Of these tourists 34 per cent camped; 38 per cent stayed at hotels; 20 per cent stayed at private homes; 8 per cent went straight through.

The count included cars from every state in the Union, also a car from Mexico and one from Canada.

Assuming the length of the tourist season as 185 days and computing from detail data collected by questionnaires and traffic count, it is estimated that $61,000,000 is spent in Missouri each year by tourists.

Rock Asphalt Top on Native Florida Rock Base

Paving the Ocean Shore Boulevard Through Flagler and Volusia Counties, Florida

By B. G. BENSON

Strange as it may seem to the thousands who think of Florida only as a winter resort, there are nearly as many thousands who flock to its inland lakes and ocean shore line for relief from the oppressive summer temperatures of more northerly states. And those who come this summer will find the Ocean Shore Boulevard completed through Flagler and Volusia counties.

This road runs southward from the north line of Flagler Beach, Seabreeze, Daytona Beach, Port Orange, Wilbur-by-the-Sea and Ponce Park. At no point does the road lie more than one mile from the Atlantic Ocean, and in sections 2 and 3, in Volusia County, there are more than 15 miles of pavement paralleling the ocean shore, east of the ocean barrier, and about 75 ft. from high water mark.

Besides opening up the country through which it runs, this road provides a straight line route between the important cities of St. Augustine, in St. John's County, and Daytona Beach, in Volusia County. It shortens the distance about 22 miles between these two cities over the Dixie Highway route (State Road No. 4). St. John's County has built a hard surface road from St. Augustine southward through Anastasia Island to Matanzas Inlet, connecting with the north end of the Ocean Shore Boulevard by means of the Matanzas Inlet Bridge, a creosted pine structure of extra heavy construction, with a bascule type draw span.

The road is approximately 41.7 miles long and 19 ft. wide, with an additional width through Volusia County of 1 ft., made up by concrete flush curbs 6 in. x 16 in. The base is made of 8-in. compressed native rock and is covered in sections 2 and 3, in Volusia County (25.2 miles), with a 1-in. (compacted) wearing surface of Kyrock, and in section 1 (16.5 miles) by Finley Method B. penetration treatment.

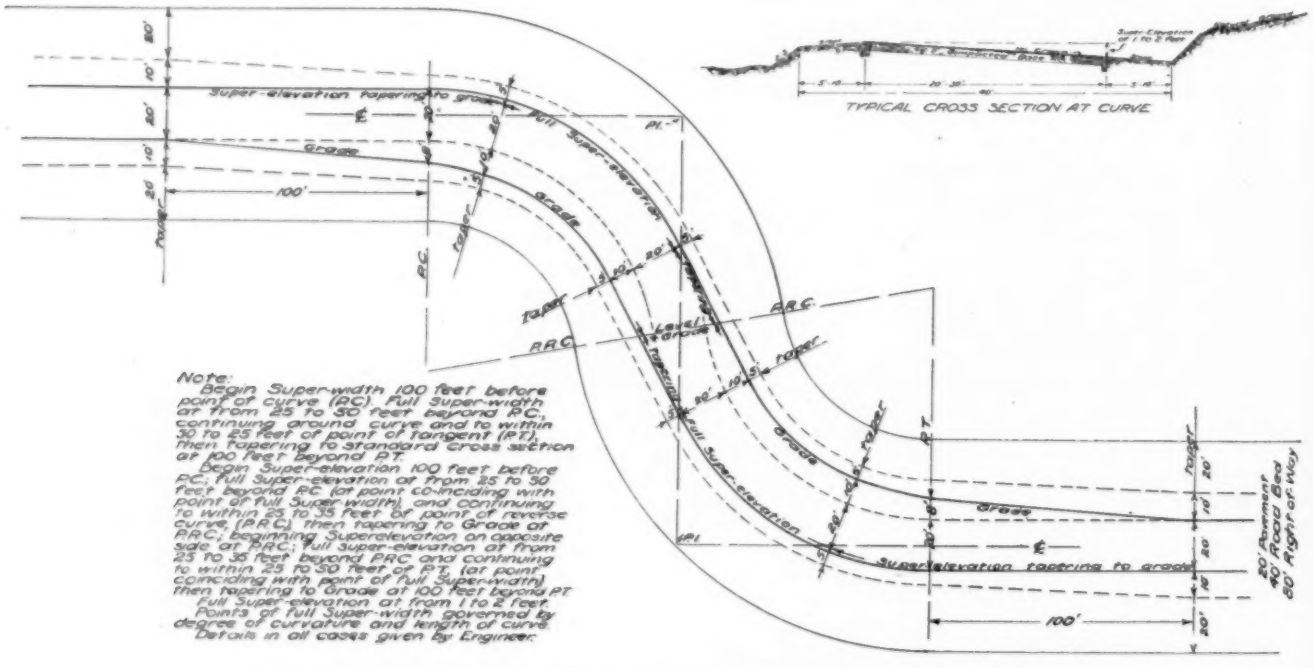
The standard cross section calls for a 2-in. crown, except on sharp curves, where the surface is made flat, but super-elevated from 1 to 2 ft. and super-widened from 7 to 10 ft., depending on the degree of curvature.

Perhaps the most interesting part of modern road building in Florida and this road in particular is the materials and methods of surfacing. Without an enduring wearing surface to waterproof the base and withstand the abrasive wear, the base of soft native rock would quickly ravel out under modern traffic. Ocala and Coquina rock used in the base of this road, like most of the native lime rock, is quite soft and chalky. Dumped on the sub-grade it is difficult to spread and is handled to best advantage with a tractor grader. Generous watering and subsequent rolling brings its natural cementing qualities into action, chokes the voids and sets it into a compact base. After the base was thoroughly dried we applied a priming coat of No. 45 road oil. This absorbs the dust particles and furnishes a tacky surface for the reception of the Kyrock wearing surface.

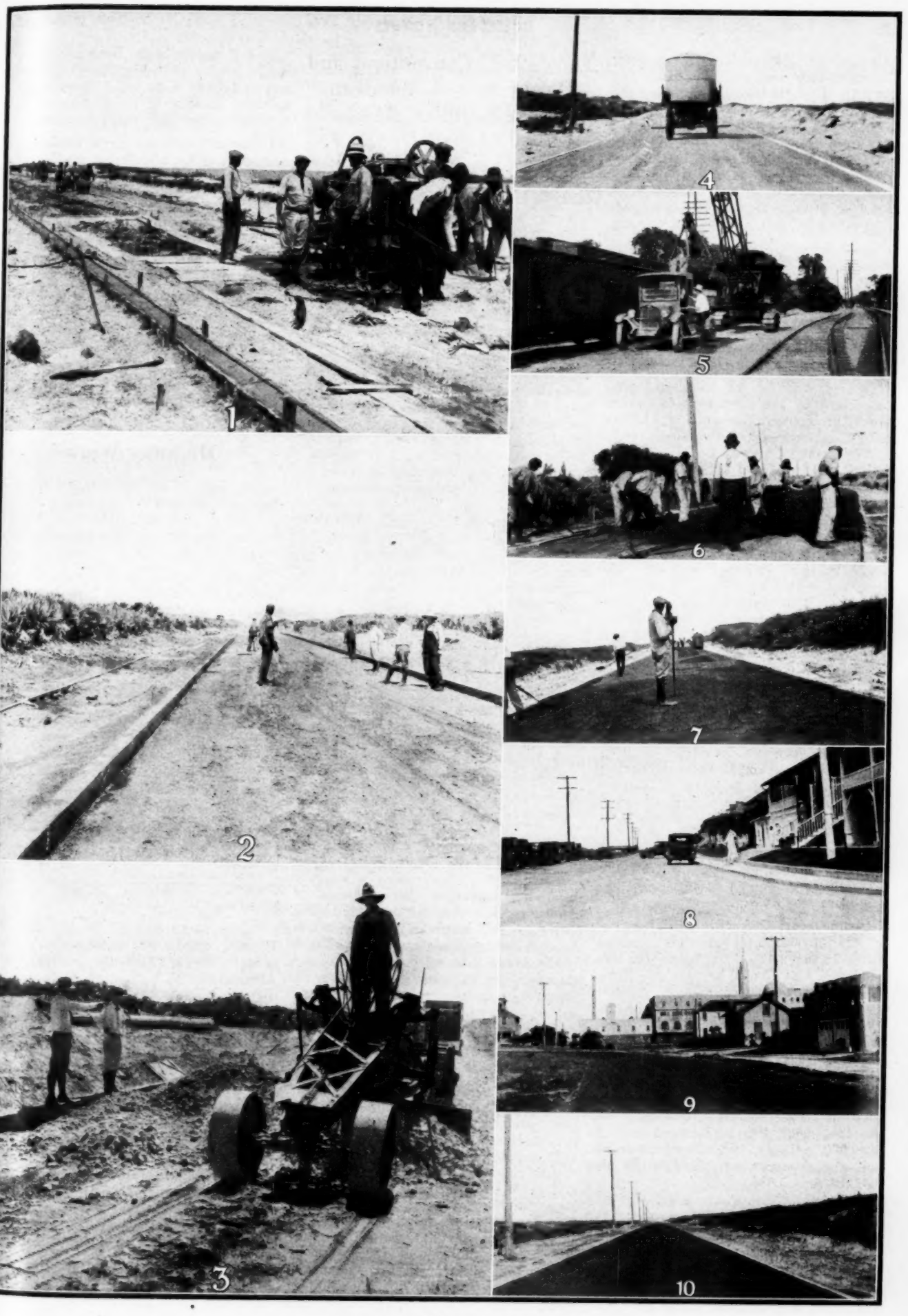
The Kyrock is laid cold. The material is unloaded from open top cars with a ¾ yd. S. & H. bucket directly into 2½-ton trucks. The trucks dump directly onto steel plates, which are attached to the trucks with chains and pulled ahead of the shovelers as the job progresses, thus saving unnecessary steps and lost motion in the shovel gang. The rakers follow immediately behind the shovelers and the roller may, if desired, and frequently does, follow immediately behind the rakers. On this job we are following the first rolling with a thin seal coat of sifted Kyrock spread with the back of a rake to correct any honeycombing or other surface irregularities which might possibly result from imperfect raking.

Following the above procedure the C. A. C. Construction Co., of Daytona Beach, lay 2,500 to 2,800 lin. ft. of 19-ft. Kyrock surface 1 in. (compacted) in a 9-hour day.

Views of the construction operations and the completed work are shown on the opposite page. (1) shows the pouring and finishing of the concrete curbs; (2) curbs stripped and sub-grade being prepared; (3) roughing in base of



Plan of Typical Layout for Ocean Shore Boulevard for Curves Greater Than Ten Degrees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Coquina rock; (4) sprinkling the base; (5) unloading Kyrock from open top car with ¾-yd. bucket; (6) dumping the Kyrock on steel plate which is pulled forward as spreading progresses; (7) spreading thin seal of sifted Kyrock; (8) Ocean Shore Boulevard in front of Ormond Beach Golf Club; (9) Ocean Shore Boulevard in rear of Coquina Hotel at Ormond Beach; (10) straightaway strip of Ocean Shore Boulevard.

The Ocean Shore Boulevard is financed by a special bond district known as the Ocean Shore Improvement District, which comprises the parts of Flagler and Volusia counties lying between the Florida East Coast Canal and Halifax River on the west and the Atlantic Ocean on the east.

The construction of this road was authorized by the electors some years ago at an approximate cost of $1,250,000. The engineering work was done by Weir and Benson of Daytona Beach, with C. M. Rogers, Daytona Beach, as consulting engineer. The general contract was let in April, 1926, the C. A. C. Construction Co., of Daytona Beach, being the successful bidder. Mr. J. K. Campbell, of the C. A. C. Co., superintends all of the construction work. The general contractor has been well equipped with men, machinery and finances and the work has been carried through at a high rate of speed and will be completed about 90 days ahead of contract time.

Canada Spent $45,563,000 in 1926

During 1926 a total of $45,563,000 was spent on construction of all provincial highways in Canada, according to computations made by A. W. Campbell, Dominion highway commissioner. Of this total $29,595,000 was spent on construction and the balance, $15,978,000, on maintenance of highways already constructed. The total mileage of roads involved in this aggregate expenditure was 46,824.

Older Ontario led with a total outlay of $21,170,000, total mileage involved being 15,861. The other provinces expenditure was divided as follows—Nova Scotia, $1,900,000, mileage 13,000; Saskatchewan, $3,925,000, total mileage, 2,400; British Columbia, $3,478,000, mileage, 4,000; Alberta, $2,140,000, mileage, 1,928; New Brunswick, $1,450,000, mileage, 1,725.

Manitoba spent $1,100,000, of which $950,000 was on construction, total mileage, 800; Prince Edward Island, $230,000, mileage, 700. The total mileage of highways constructed in Canada in 1926 was 5,788.

Minnesota Law Helps Road Men.—A new law recently passed by the state legislature and signed by the governor authorizes first class cities in Minnesota to acquire property and easement for street and highway purposes.

The 1928 Convention and Road Show of American Road Builders' Assn.

The 1928 Convention and Road Show of the American Road Builders' Association will be held in Cleveland, O., Jan. 9th to 13th.

After carefully considering invitations from several cities, it has finally been decided that the next convention of the Road Builders should be held in Cleveland on account of the many facilities that that city affords and which will permit of a larger and more interesting exhibit.

The exposition will be held in Cleveland's Auditorium and Annex, where every facility for a successful exhibition is to be found. There is available 45 per cent more area than was used in Chicago, with facilities such as railroad tracks immediately adjacent to the exhibition building. With less expense to the exhibitor, a more satisfactory exhibit may be made and more space secured than in previous years. This lack of space during the past few years has been a severe drawback to the many exhibitors who have desired to show improved machines and materials that they were not able to exhibit in Chicago because of the restricted space.

An excellent arrangement has been made with the convention board of the Cleveland Chamber of Commerce by which all hotel reservations will be made through a central bureau, thus assuring everyone of satisfactory hotel accommodations. Definite and detailed arrangements as to how reservations should be made will be made public later.

The American Road Builders' Association at the present time is organizing a division of county officials and one of the features of the 1928 convention will be county officials' day, when papers and discussions covering the problems of county officials will be presented. The entire day will be given up to the activities of county officials and the officers of the day will be selected from county officials.

Due to the fact that there will be very few legislatures in session during 1928, it has been decided to observe Governors' Day, and it is expected that a large number of governors from the various states will be in attendance.

The great success of Pan American Day, which was participated in by twelve Pan American countries at the 1927 convention, has demanded that this day be observed at the 1928 convention; and extra effort will be made to have a larger number of countries represented. The Pan American countries will be invited to send exhibits and these, together with the exhibits presented by the several states, will form a special exhibit in one of the large exhibition halls.

The Road Builders' banquet has already grown to enormous proportions and in 1928 it is expected there will be a larger number of road builders than ever before at this yearly function.

In order to attract large numbers of people to the convention a special program is to be presented. One day will be given over to county officials' problems, one day to the usual highway engineering features and another day to traffic problems. A program setting forth the contractors' problems and progress will be held as usual.

The location of Cleveland is such that it is easily accessible by railroad and the moving of the convention easterly makes it especially attractive to the eastern states, which should send a large number of delegates.

New Bond Issues to Finance Highway Work

Over half of the $45,894,106 in new state and municipal bond issues scheduled during one week recently by eighty communities will be used for road construction work.

North Carolina opened bids for an issue of $20,000,000 and Illinois was in the market for $6,000,000 highway funds. South Dakota borrowed $4,000,000 for rural credit refunding purposes. The previous week's total was $35,185,830.

The following list of important items is compiled from a calendar of public bond offerings published by the Bond Buyer for the one week.

Monday—Winter Park, Fla., $210,000; Kingston, Pa., school district, $800,000; North Carolina, $20,000,000; Royal Oak, Mich., $525,000; Freeport, N. Y., $325,000; Sarasota, Fla., $204,000; Tama county, Iowa, $300,000; Brookline, Mass., $300,000; Iron River township, Michigan, school district, $250,000.

Tuesday—Clewiston drain district, Florida, $200,000; Kansas City, Mo., school district, $2,000,000 or $1,000,000; Alexandria, N. Y., Union Free school district No. 5, $325,000; Illinois, $6,000,000; South Dakota, $4,000,000; New Bedford, Mass., $750,000.

Wednesday — Middletown, N. Y., $490,000; Mahaska county, Iowa, $200,000.

Thursday—Monroe county, Florida, $498,000; Williamsport, Pa., school district, $300,000; Wapello county, Iowa, $250,000.

Friday—Des Moines county, Iowa, $400,000; Minneapolis, Minn., $210,000; Cumberland county, North Carolina, $1,460,000; Long Beach, Cal., $500,000; Maine, $500,000.

Saturday—Dane county, Wisconsin, $731,000; St. Clair county, Michigan, $553,800.

Grading Approaches to Carquinez Straits Bridge

How the 250,000 Cu. Yds. of Excavation for 2½ Miles of Highway Was Handled

The construction of the approaches to the recently opened Carquinez Straits highway bridge at the head of San Francisco Bay, Calif., involves one of the largest earth moving jobs in the history of California highways. The work requires the building of 2½ miles of highway, involving the excavation of more than 250,000 cu. yd. of earth.

About 1.8 miles of approaches were built on the south end of the bridge and a 4,200-ft. approach on the north end.

The south highway approach was constructed by Tioslau Brothers, of Berkeley, Calif., under contract from the California State Highway Commission, and the north highway approach by the Stanley Construction Co., of Palo Alto, Calif., under a road district plan.

Excavation of 207,000 cu. yd. of material was necessary in building the 1.8 miles of the southern approach. Large cuts and fills were made. One of the cuts necessary to the bridge approach was 500 ft. long, 106 ft. deep and 100 ft. wide. Eighty-three thousand yd. of earth were taken from this cut alone.

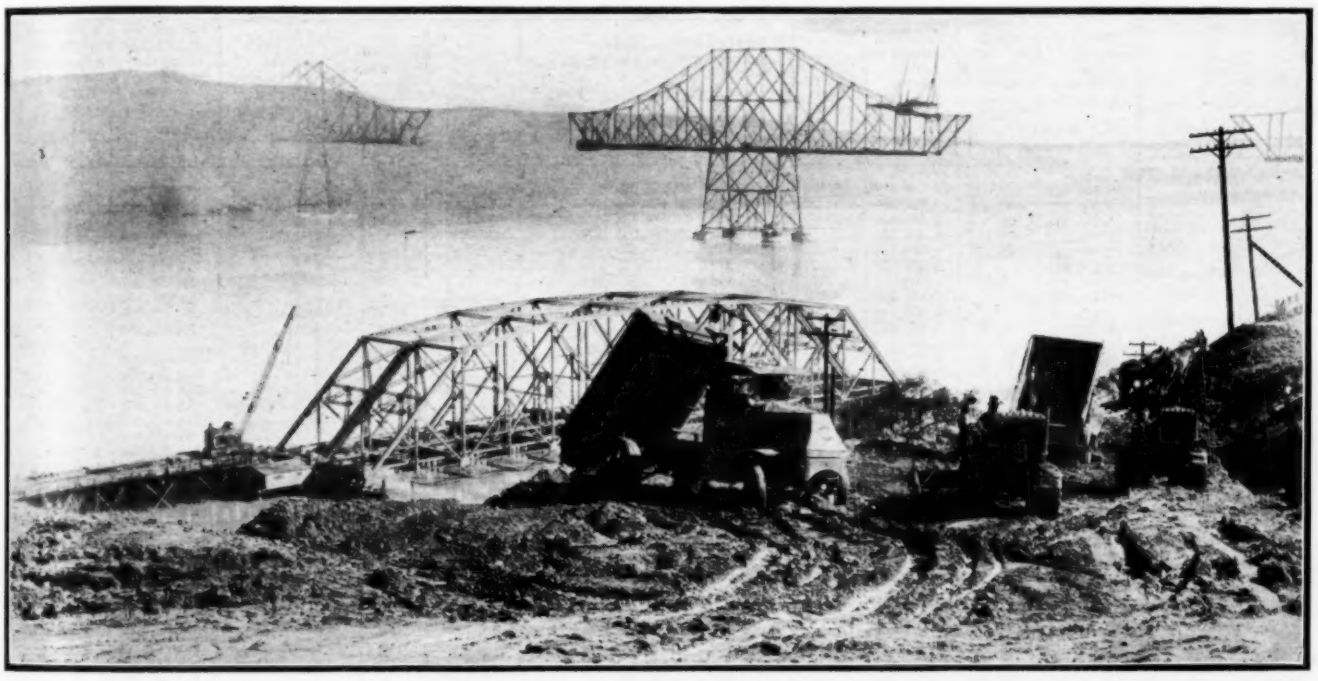
Dirt moved from this excavation was used for fill purposes, one fill being 50 ft. deep. Under the requirements of the contract, dirt was spread in 1-ft. layers and then rolled with trucks, tractors and other heavy equipment in order to insure the use of the road immediately without disastrous settling or sliding.

Heavy duty equipment on the job included two "Caterpillar" Thirty tractors, two Koehring gasoline shovels and heavy dump trucks. The "Caterpillars" were used to move the shovels, haul the loaded trucks out of the mud during wet weather, to pull the trucks back from the edge of the road where the spoil from the shovels was dumped, and to haul scrapers and a Russell standard grader.

Plenty of grief was encountered by the contractors when an unusually wet rainy season caught them with limited time and a fixed finish date. Several bad slides resulted and the ground was so softened as to slow up truck operation. "Caterpillars" were pressed into service and with these trucks were hauled through the heavy mud. For a time three shifts were on the job, and toward the end two shifts were used.

On the north approach to the bridge the Stanley Construction Co. used two Northwest gasoline shovels, White trucks and a "Caterpillar" Thirty to haul the trucks out of heavy going, to handling scrapers and for leveling and grading road.

Sixty thousand yards of earth were moved from a deep cut at the bridge head and used to bank a lengthy shallow fill connecting with the main highway near Vallejo.



Constructing Fill for Roadway to the Carquinez Straits Bridge—One of the Center Spans Under Construction Is Shown in the Background

Weather Bureau Aids Bridge Construction

During the recent construction of the Carquinez Straits bridge at Crockett, Calif., said to be the largest cantilever bridge in the world, two steel spans weighing 750 tons each were built on shore, towed on pontoons out into the straits, and hoisted by means of counter-weights to the level of the bridge, 135 ft. above the water. The towing and lifting of these spans, which required several hours, could not be safely undertaken except under favorable weather conditions. High winds or rough waters would probably have resulted in the loss of the spans by collapse or sinking, entailing an expense of hundreds of thousands of dollars, and possibly some fatalities to the workmen.

In view of these facts, the construction company asked the Weather Bureau of the United States Department of Agriculture to detail a meteorologist to make special observations at the straits and advise the engineers as to the best time to proceed with the work. A man was accordingly detailed from the Weather Bureau office in San Francisco, an anemometer was installed on the completed portion of the bridge, and current weather indications were supplied by long-distance telephone from San Francisco. Both spans were successfully raised, one on March 3 and the other on March 19, 1927, in accordance with advice furnished by the meteorological expert. The construction company has expressed its high appreciation of the services rendered by the Weather Bureau on this occasion.

The Gas Tax and Its Disposition

Figures collected by the U. S. Bureau of Public Roads show that the total net tax earnings by the various states on gas for motor vehicles amounted to $187,603,231 in 1926. Of this total $129,441,520 was expended on the construction and maintenance of state highways and $43,609,479 was used for local roads. The sum of $5,238,869 was applied on state and county roads bond payments. Michigan alone using $4,082,000 for this purpose.

In addition $9,074,466 of the total gas funds was applied for miscellaneous purposes by the various states. Georgia used $1,613,982 for the state general treasury fund and Texas and Ohio applied $1,306,721 to the free school fund. Several of the states applied part of their gas tax earnings to the city streets. Maryland used $458,271 for the maintenance of streets in Baltimore, and Ohio applied $3,977,180 for the repair and maintenance of city streets.

The average tax rate in 1926 was 2.38 per gallon. Two states, Kentucky and South Carolina, had a tax rate of 5 ct. per gallon; one state had a tax of 4½ ct., and four states had a tax rate of 4 ct. Only four states, Illinois, Massachusetts, New Jersey and New York, had no gas tax in 1926. It was estimated that the total gas consumption in these four states amounted to 1,905,000,000 gal., as compared with 7,883,983,500 gal. in the states having a gas tax. The accompanying tabulation gives some interesting data on the gasoline taxes in 1926:

GASOLINE TAXES FOR THE YEAR 1926

State	Gross tax assessed prior to deduction of refunds	Exemption refunds (deduct from gross tax)	Total tax earnings on fuel for motor vehicles [1]	Disposition of total tax earnings					Tax rates, 1926			Net gallons of gasoline taxed and used by motor vehicles	Estimated additional gallons (not taxed) used by motor vehicles
				Collection costs [2]	Construction and maintenance of rural roads		State and county road-bond payments	Miscellaneous	Cents per gallon		Date of rate change		
					State highways	Local roads			Jan. 1	Dec. 31			
Alabama	$2,558,651		$2,558,651	$9,582		$2,549,069			2	[3] 2		127,932,538	
Arizona	1,206,660	$228,396	978,264		$489,132	489,132			3	3		32,608,821	
Arkansas	3,785,304	200,000	3,585,304		1,991,834	684,488	[4] $908,982		4	4		89,632,594	
California	17,910,077	1,407,954	16,502,123		8,251,062	8,251,062			2	2		825,106,169	
Colorado	2,169,456	77,707	2,091,749	[5]	1,045,875	1,045,874			2	2		104,587,460	
Connecticut	2,689,372		2,689,372		2,689,372				2	2		134,468,607	
Delaware	399,309	8,895	390,414		390,414				2	2		19,520,687	
Florida	11,431,486		11,431,486	8,400	8,567,315	2,855,771			4	4		285,787,156	
Georgia	5,653,140		5,653,140	4,200	2,420,974	1,613,983	[6] $1,613,983		3½	3½		161,518,296	
Idaho	1,182,584	60,367	1,122,217	6,820	1,115,397				3	3		37,403,986	
Illinois									0	0	No tax.		650,000,000
Indiana	9,213,828	242,087	8,971,741	11,902	5,973,226	2,986,613			3	3		299,058,025	
Iowa	5,020,086	177,659	4,842,427	10,736	1,610,564	3,221,127			2	2		242,121,370	
Kansas	4,406,653	103,265	4,303,388	[7]	3,576,210	727,178			2	2		215,169,393	
Kentucky	4,935,078		4,935,078	[8]	4,935,078				3	5	Feb. 21	103,477,662	
Louisiana	2,708,567		2,708,567		2,708,567				2	2		135,428,367	
Maine	1,864,596	[9] 41,250	1,823,346	10,069	1,511,064	302,213			3	3		60,090,659	
Maryland	2,357,577	63,723	2,293,854	2,500	1,833,083			[10] 458,271	2	2		114,692,672	
Massachusetts									0	0	No tax.		280,000,000
Michigan	10,758,109	676,333	10,081,776	23,737	4,764,422	[11] 1,211,557	4,082,060		2	2		504,088,814	
Minnesota	5,072,854	268,166	4,804,688	[12]	4,804,688				2	2		240,234,382	
Mississippi	[13] 4,088,200		4,088,200	3,150	1,940,186	1,990,912	[14] 50,727	[15] 103,225	3	4	Apr. 1	105,887,426	
Missouri	5,777,163	116,018	5,661,145	54,698	5,606,447				2	[16] 2		283,057,270	
Montana	870,712		870,712		131,002	477,707		[6] 262,003	2	[16] 2		43,535,576	
Nebraska	3,055,705	15,778	3,039,927	7,028	3,032,899				2	2		151,996,357	
Nevada	433,820	28,002	405,818		202,909	202,909			4	4		10,145,454	
New Hampshire	781,453	12,871	768,582		768,582				2	2		38,429,100	
New Jersey									0	0	No tax.		255,000,000
New Mexico	762,851		762,851	25,428	737,423				3	3		25,428,358	
New York									0	0	No tax.		720,000,000
North Carolina	8,113,044	326,571	7,786,473		[17] 7,786,473		[18]		4	4		194,661,825	
North Dakota	1,083,531	95,038	988,493		820,101			[6] 168,392	1	2	July 31	73,689,462	
Ohio	13,556,253	298,987	13,257,266		5,965,770	3,314,316		[17] 3,977,180	2	2		662,863,296	
Oklahoma	6,237,989	[19] 25,580	6,212,409	[20]	4,141,606	2,070,803			3	3		207,080,296	
Oregon	3,536,142	202,313	3,333,829	7,693	3,326,136				3	3		118,493,937	
Pennsylvania	[21] 11,781,782		11,781,782		8,709,213	2,903,071		[6] 169,498	2	2		588,379,021	
Rhode Island	629,024	117,128	511,896	[22]	511,896				1	1		51,189,641	
South Carolina	4,505,694	8,726	4,496,968	[23]	2,698,181	1,798,787			5	5		89,939,352	
South Dakota	2,284,761	360,003	1,924,758		1,924,758				3	3		64,158,589	
Tennessee	3,852,524		3,852,524	38,525	3,813,998				3	3		128,417,453	
Texas	5,228,009	1,123	5,226,886		3,920,164			[24] 1,306,721	1	1		522,688,578	
Utah	1,258,009		1,258,009	3,750	1,057,159		197,100		3½	3½		35,943,117	
Vermont	553,093		553,093	[25]	553,093				2	2		27,654,594	
Virginia	6,158,124	302,454	5,855,670	[26] 697	3,903,316	1,951,657			3	4½	Mar. 11	135,814,061	
Washington	3,701,676	219,583	3,482,093	[27]	3,482,093				2	2		174,104,636	
West Virginia	3,001,131	78,456	2,922,675	[28]	2,922,675		[27]		3½	3½		83,504,998	
Wisconsin	5,373,667	163,862	5,209,805	9,982	2,238,574	2,961,250			2	2		200,490,262	
Wyoming	571,449	2,860	568,589		568,589				2½	2½		22,743,572	
District of Columbia	1,020,050	4,857	1,015,193					[29] 1,015,193	2	2		50,759,671	
Total			187,603,231	238,897	129,441,520	43,609,479	5,238,869	9,074,466	Av.	2.38		7,883,983,560	1,905,000,000

[1] The net tax after deduction of refunds for exemptions according to law and represents the actual taxes available for disposal. The first 2 columns show only the procedure and are not totaled.

[2] Collection costs in many States are paid from other State funds, and when amounts and sources are reported notes are entered below

[3] Changed to 4 cents on Jan. 4, 1927

[4] Allotted by appropriation out of gasoline tax fund, but claims exceed this by $225,000.

[5] Collection costs charged to State controllers office fund.

[6] For State general treasury fund.

[7] Paid $8,750 from general revenue of State.

[8] From general State fund.

[9] Refund of 2 cents only, allowed by law.

[10] For maintenance of Baltimore Streets.

[11] State rewards to counties.

[12] Paid from oil inspection appropriation.

[13] Includes $103,225 from extra 2-cent tax collected from Harrison County for sea wall to protect State highway in this county.

[14] Sea-wall bonds.

[15] Changed to 3 cents on January 1, 1927.

[16] Large part of State highway share is paid for interest and sinking fund on State highway bonds.

[17] For repair and maintenance of municipal streets.

[18] Deduction of 3 per cent allowed for evaporation.

[19] Paid $17,616 from State funds.

[20] Includes $14,202 from delinquent 1 cent tax due in 1921-1923.

[21] State appropriation of $5,000.

[22] For free school fund.

[23] Collection cost of $500 from motor vehicle bureau appropriation.

[24] Only part of cost, remaining cost of $5,803 is from State appropriation.

[25] From Motor vehicle license fund, $5,000.

[26] State appropriation of $7,500.

[27] State road bond payments taken from gasoline tax, amount not reported.

[28] For Washington Streets.

Reconstruction and Maintenance by Contract

An interesting Discussion on the Possibilities of Handling This Work by Contract Given in Address At 8th Annual Meeting of Associated General Contractors of America

By G. F. SCHLESINGER

Director, Department of Highways and Public Works, State of Ohio

The meaning of the term highway "maintenance" is not fixed and the exact operations included may vary with different highway organizations. Maintenance, in the dictionary sense, means to preserve something in its original condition. In many states all forms of routine repairs, resurfacing, reconstruction, including widening and minor grade and alinement changes are classified as maintenance — frequently in order that they may be eligible to receive a certain class of appropriated funds. In private industry, such as a railroad company, it is important that any expenditure for reconstruction that is greater than that required to "renew in kind" is classified as an addition and betterment and a strict accounting made of the same. The company is thereby enabled to capitalize this account and increase its credit and borrowing powers.

While most highway departments make attempts to distinguish between betterments and routine maintenance there is not the incentive in the way of financial advantage for a rigid classification. In this discussion of highway maintenance that is adaptable to the contract method maintenance will be considered in a broad sense as including all work necessary to make an existing highway economical, safe and convenient for travel. In this sense such service as the erection of warning signs, route markers, the maintenance of detours, the removal of snow, etc., are logically part of the functions of a maintenance organization.

What Highway Maintenance Covers.—There are a considerable variety of operations involved in the maintenance of a modern highway. The quantity and kind of maintenance necessary to apply to a road will vary greatly with conditions. The surfacing may consist of any thing from native earth to the highest type of pavement. The quantity and nature of the traffic has its effect not only on the amount but also on the standard of maintenance. Difference in topographic, geologic, and climatic conditions is reflected in the kind of treatment it is necessary to give the road. Following is a list of maintenance operations taken from the record of the Ohio Division of Highways:

SURFACE

Bituminous Surface Treatment.
Screening Surface.
Bituminous Paint Patching.
Bituminous Wave Patching.
Mixing Bituminous Patch Materials.
Taking Out Crown.
Sealing Edges.
Widening Curves.
Superelevating Curves.
Widening Surface.
Resurfacing.
Repairing Pavement Failures.
Sealing Cracks.
Refilling Surface (Brick).
Transporting Materials.
Removing Snow.
Cindering Slippery Surface.
Maintaining Detours.
Dragging Surface (Traffic Bound Roads).
Applying Metal to Surface (Traffic Bound Roads).
Applying Dust Palliatives (Traffic Bound Roads).
Metaling Side Roads (on one-lane Pavements).
Building Turnouts (on one-lane Pavements).
Quarrying and Crushing of Materials.

ROADBED

Increasing Sight Distance.
Widening Roadbed.
Scalping Shoulders.
Metaling Ruts.
Metaling Shoulders.
Building Up Shoulders.
Seeding Shoulders.
Opening Ditches.
Opening Drains.
Dressing Slopes.
Removing Slips.
Constructing Drains (tile or blind).
Repairing Guard Rail.
Painting Guard Rail and Poles (including cold water paint and whitewash).
Erecting Guard Rail.
Mowing Weeds and Brush.
Grading Roadbed.
Dragging Shoulders.
Dragging Side Roads.
Metaling Side Road Approaches.
Repairing Side Road Drains.
Riprapping.
Cribbing.

MISCELLANEOUS

Repairing Washouts.
Repairing Bridge Floors.
Repairing Drainage Structures.
Repairing Signs and Markers.
Erecting Signs and Markers.
Making Signs and Markers.
Painting Center Lines and Pavement Marking.
Painting Bridges.
Building Small Retaining Walls.
Pile Driving.
Stream Relocation.
Investigating Accidents.
Trapping Ground Water.
Paving Gutters.
Building Breakwaters in Streams.
Building Breakwaters on Slopes.
Construction Temporary Bridges.
Repairing and Overhauling Equipment.
Erecting Garages and Equipment Storage Buildings.
Repairing Buildings.

Why Highways Fail.—The fact that maintenance and reconstruction are necessary frequently calls forth criticism, and the "failure" of roads is a fertile subject of comment on the part of the public. The use of the word "failure" in this connection is unfortunate in that it implies incompetency, negligence, or culpability on the part of the highway engineer or contractor. That so-called road failure is the fault of either the designer or constructor is not necessarily nor usually true.

It is generally recognized that our troubles in the way of road failures have come largely from the change in character of the traffic rather than from the increase in the quantity of traffic. The annual expenditures on roads under supervision of the state highway departments per thousand of motor vehicles registered have been increasing from which fact we can conclude that new construction of state roads has more than kept abreast of motor vehicle registration. Due allowances should be made for the fact that traffic undoubtedly increases at a greater rate than registration as the distance travelled annually per motor vehicle has increased with better highway facilities. Without raising the question as to whether the rate of new construction has been great enough, it is apparent from data available that the sudden necessity for large reconstruction programs for the older highway systems has been principally due to the advent of motor truck traffic.

The motor bus which has come into extensive use has not introduced any increased concentrated loading. However, it will require that pavements be constructed wider than formerly.

Economic Life of a Pavement.—It is expected that roads, like any other engineering structure or machine, will depreciate. Even with the most efficient maintenance a point is reached when it is more economical to reconstruct the pavement than to spend excessive sums in endeavors to prolong its life. When that point is reached the pavement has attained its economic life. If we possess accurate data on initial costs, salvage values, and maintenance costs the economic life of a pavement can be determined. Whether the highway official is in position to act in accordance with the economics of the problem always depends on the funds available. Economically reconstruction may be proper but due to financial limitations we are frequently compelled to continue repairing the existing surface.

The principle of stage or progressive construction of roads contemplates that the original surfacing is inadequate for the traffic that will be expected in the future. The engineer plans to use the existing road metal as a foundation for a heavier type of construction as funds become available with increased traffic. It is considered more economical to connect centers of traffic flow at once, and then later to build vertically rather than horizontally in order to meet the requirements of increased traffic and economic maintenance.

In certain types of construction, such as traffic bound gravel, stone or sand-clay, instead of periodic attention the

maintenance work necessary consists of a constant renewal and reconstruction of the surface. As is well known, lack of attention for only a day or two will result in dismal failures in this type of road surface.

Importance of Highway Research.—However, in connection with the subject of road failures the engineering profession can not be considered to be entirely without fault. Until comparatively recent years the knowledge of the art of road design, construction and maintenance lagged behind the increase in the volume of road mileage being constructed and maintained. The importance of highway research was not realized for many years. The fact that the highway engineers were too busily engaged in a frantic effort to keep pace with the enormous increase in motorized highway traffic can be given as an extenuating reason. Progress in research due to a number of important investigational projects carried on by public and private agencies has resulted in more rational and economical design methods of all types of pavements. The establishment of the Highway Research Board as a co-ordinating agency insures for the future an efficient and proper dissemination of highway research knowledge among those who are responsible for the large road programs.

A certain class of road failures is due to special causes, such as unusual rain storms, extensive land slides, effects of temperature, and traffic concentration due to deep snow. Many in this class are beyond the control of the engineer, or of such infrequent occurrence that it is not considered economic to provide against them in the design.

The adequate maintenance of an existing highway system should be the first obligation of any highway organization. Expenditure of funds for an expansion of highway mileage at the expense of the neglect of roads already constructed is the crassest folly. The investment of the public in road improvements should be preserved. Popular sentiment, good sense, and sound economics have demanded such a policy and justly so.

Increasing Need of Maintenance.—In the early years of the present era of the development of highway transportation, new construction was the dominating activity. Maintenance was of very minor importance because the newly constructed "permanent" roads required very little attention. The small repairs necessary were of the class that could best be done by direct labor employed by the highway authorities. There was no maintenance work of the magnitude that would prompt any thought of the contract system. One of the principle subjects of discussion at that time was the relative merits of the patrol or gang systems for making repairs with direct labor. In a few years the unforeseen development in motor vehicular traffic began to cause the destruction of road surfaces and create maintenance and repair problems of a magnitude never dreamed of in the beginning. It was natural that highway departments should expand existing direct labor forces in order to handle the larger repair projects such as the reconstruction and widening of highways. It has become, perhaps, second nature to consider any operation, classified as maintenance, as one to be performed by direct labor regardless of its size or character.

Contract System Preferable to Day Labor Work.—The writer favors the general principle that the private contract system is preferable to day labor methods on public work. A democratic form of government such as that of the United States does not call for the supplanting of private enterprise with governmental agencies. In fact the greatness and prosperity of our country has rested largely upon the encouragement of private industry in all lines of endeavor. There is no reason why the highway construction industry should be an exception. Most highway officials are convinced from their own experiences that the performance of highway projects by direct labor methods is not as economical as by contract. Centralized control of state highway operations is necessary but the maintenance of a large personnel and the investment of funds in road equipment for work that can be done by contract should be avoided wherever possible.

However, a reference to the maintenance and repair operations listed above will show that in many cases it would not be feasible to let them by contract. The principal objection to the contract method is based on the impracticability of formulating definite plans in advance of the work. This is necessary as a matter of fairness to the bidders, to enable the awarding authority to secure a proper comparison of the bidders, and to avoid the evil of over-run and unbalanced items. While it is true that this objection applies to relatively minor operations, in the aggregate they comprise a large share of the total maintenance expenditures.

Discussion of Limitations of Contract Work.—Among other disadvantages and limitations to performing highway maintenance by contract the following are often advanced and will be discussed in order:

(1) For certain types of maintenance work the contract system is not sufficiently flexible. Two outstanding examples are snow removal and the maintenance of detours. These operations constitute a very essential service to the traveling public and should not be delegated by contract to agencies other than employes of the highway department. Requiring the contractor to maintain detours as a part of his contract has been tried and found decidedly unsatisfactory. The amount and location of snow removal in most states are such variables that the degree of flexibility in forces and equipment necessary precludes the contracting of this work. Certain kinds of repair work such as small patching, sealing cracks, constructing small culverts, cleaning ditches, etc., can be much more opportunely prosecuted by direct labor. Traffic bound sand-clay, gravel, or stone roads, maintained by dragging, require the most timely attention. This work will vary greatly with weather conditions. Its general attenuated nature also makes it undesirable to contract from the standpoint of both the highway authorities and the contractors.

(2) The contract system involves undue delay. Before bids are received on public work contracts, a certain amount of red-tape procedure must be followed which consumes time. It is believed that this criticism is not valid, as with a good budget system most maintenance work that is susceptible to the contract system can be anticipated and planned for in advance. When it comes to the purchase of equipment and materials necessary to pursue the work, the contractor has the advantage from the standpoint of expediting matters as the same delay due to red-tape is involved in their purchase by public authorities as in letting contracts. However, there are emergency conditions of comparatively infrequent occurrence that do not permit of delay. Land slides and slips, floods, wash-outs, and sudden pavement failures are in this class.

(3) An inferior quality of work is obtained by contract. There are undoubtedly some grounds for this charge as applied to the class of contracts that are not of sufficient size to attract competent contract organizations. For example, contract work on traffic bound maintenance, consisting of small contracts frequently located in isolated territory, is often bid in by local contractors of a decidedly "small-fry" caliber. It may be a just criticism in the case of much maintenance work that requires great care and specialized effort —such as bituminous patching and surface treatment (especially an initial application). It is believed, however, that with time and patience a clientele of contractors, qualified to perform so-called specialized maintenance work, can be established. With the increase in volume of such work the contractor's organization can, with experience, acquire the required skill. Exercise of intelligence by highway officials in the selection of "qualified" bidders, and strict and impartial inspection will aid materially in producing the desired results.

In reconstruction work of a larger magnitude the question as to which system—contract or direct labor—will produce the better quality of work, is indeed debatable. It may be argued that there is no financial advantage to the state in "skinning the job" when performed by direct labor. On the other hand to permit a contractor to violate

requirements of specifications is a reflection on the engineering supervision and inspection and not a valid criticism of the system. How often have contractors and highway engineers alike observed practices in direct labor operations that would not be tolerated on a contract job. The former is usually carried on under the direct control of non-technical superintendents without the degree of engineering inspection that obtains on a contract. Non-conformity with the provisions of the specifications are not taken as serious. The element of mental vigilance that exists in both the inspector and contractor is missing.

(4) Contract work is less economical. Such a conclusion is predicated on the theory, that in a direct labor operation the contractor's profit and cost of inspection are saved. This gain is more theoretical than real, being counterbalanced by other factors that increase the expense of direct labor work. Little reliance can be placed on figures that have been issued by highway departments on the cost of direct labor projects unless they are substantiated by a thorough investigation to determine whether all items—direct and indirect—that enter into the cost have been included. It is one of the fundamental qualities of human nature that a man will give more careful attention to work from which he derives a financial benefit by being efficient than to work in which his salary is not directly affected by any results produced short of complete failure. This principle is recognized by industry which in many cases is giving the employes a financial interest in the business. The psychology of the situation is detrimental to the economical performance of public work by direct labor. Many workmen, material and equipment companies, citizens who sell right-of-way and claim damages, and people in general consider government a legitimate prey and govern their actions accordingly. In this statement of fact no reflection is intended on the many faithful and conscientious employes in public service.

It is true that where experienced contractors have not been developed to perform specialized maintenance work, direct labor may at first be more economical than by contract. Competition is limited and those who compete bid high because they are unfamiliar with the work. However, in the long run, after qualified contractors are developed the initial disadvantage will be more than offset by the subsequent gain. It has only been a few years since highway contracting on new construction was an infant industry, and a similar situation was experienced.

Ohio Does Over 50 Per Cent of Its Maintenance by Contract.—The Ohio Division of Highways, believing it desirable to perform maintenance work by contract when feasible, has for several years made a consistent effort to practice this policy. From 1917 to 1923 the percentage of the total expenditures for maintenance by contract varied from a minimum of 6 to a maximum of 20. Since 1923 it has increased at a fairly uniform rate to a maximum of 53 per cent in 1926.

In Ohio the law for several years has provided that all highway work, both maintenance and construction, estimated to cost more than $3,000 per mile, must be done by contract. The highway department recommended a limit of $5,000, but this was reduced by the law makers. The wisdom of any such legal restriction can be questioned on several grounds.

It may be maintained that the highway department executives should not have their freedom of judgment and action hampered by such restriction. A condition might arise where fair and open competition does not exist and such a law takes away from the administrative official a means of corrective. The legislature, however, evidently discounted the objections.

It recognized that the enforcement of the principle that highway improvement by contract is to the best public interest might be endangered by the whims of the individuals who determine the policy of the highway department.

While the present highway department would prefer that the limit be raised to $5,000, with provisions for an increased amount for emergency work, the law has in general been satisfactory in its operations. Nor does this law by any means account entirely for the increased proportion of maintenance by contract in Ohio. At least half of the work let by contract in 1926 was not affected by the law in question.

Repair and Painting of Steel Bridges by Contract.—The variety of operations has increased with the total amounts and proportions let by contract. It is believed that for certain items such as bituminous surface treating, erecting guard rail, and the maintenance of steel bridges the amount done by contract in the future will be increased. Regarding the repair and painting of steel bridges following is the opinion of J. R. Burkey, Chief Engineer of Bridges of the Ohio Division of Highways:

"The maintenance and repair of steel bridges is a specialty involving certain operations, in many cases, which our maintenance forces are not equipped to do. For instance, when we renew or repair the floor of an old structure, it is our policy to take advantage of the lightened condition of the structure, to jack up the bridge, clean out the rollers and, in many cases, renew same since they are generally the worst corroded portion of the structure. Frequently, connections are so badly rusted that they need replacing. Any new steel work that is required in connection with this work generally requires shop work and measurements taken for this shop work necessarily must be precise since the responsibility for the final fit depends upon these measurements. For this reason, it is desirable to contract this work, in which case, our specifications require that the contractor will be responsible for any detail measurements involved in the fitting of new work with old.

"The matter of tightening up steel bridges requires a special experience which the state cannot afford to hold in readiness for such occasional work. This again should be done by structural bridge contractors under the direction of the maintenance engineer or bridge bureau.

"The painting of large steel bridges can be done by contract as economically as by maintenance and, to my mind, it is questionable whether it cannot be done better. In many cases, it requires special equipment together with experience in handling this equipment on account of the hazards that are involved."

Maintaining Unpaved Highway by Contract.—In 1924 the Ohio Department of Highways decided to embark on the policy of maintaining the unpaved sections of the state highway system. This accounts for the relatively large expenditures in the last three years for traffic-bound maintenance, practically all of which was performed at first with direct labor. Placing over 3,000 miles of traffic-bound roads under maintenance in three years could not have been accomplished unless a large portion of the work had been contracted. At first it was difficult to secure competent bidders due to the jobs being so small in amount and the work unfamiliar to Ohio contractors. At present there exists a fairly satisfactory corps of qualified bidders, although there is still room for improvement.

All projects of any magnitude are let using the same procedure as in new construction contracts, including advertising, bidder's certified check, and surety bond. Bidders are required to submit standard experience questionnaires and financial statements recommended by the Joint Conference on Construction Practices, to assist in the determination of the "lowest and best" bidder. In 1926, 71 per cent of the maintenance contracts were awarded in this manner. Smaller contracts are let more informally on departmental orders, although an effort is always made to secure full competition from bidders who are in position properly to handle the work. On many small projects the contractors have not been required to furnish a surety bond, but the department has found this policy unsatisfactory and will require a bond on practically all contract work in the future. All contracts are on the unit-price basis.

Highway Authorities Should Consider Contract Work.—In a previous discussion, "Resurfacing and Maintenance Work as a Future Field for the Contractor"—1926 Convention Proceedings

of the American Road Builders' Association, Page 240—the writer has estimated that the total expenditures for maintenance and resurfacing in the United States for the next five years will be about $1,600,000,000. It is the belief of many students of the problem that a considerable saving in these expenditures can be effected by the use of the contract system when feasible. It is the duty of highway authorities to give thorough consideration to this method of handling future highway maintenance work.

It may be expected that the new construction curve will at some time in the future assume a downward trend. It will undoubtedly be many years before the peak is reached, considering that less than one-fifth of the total mileage of rural highways in the country have had some type of surfacing. It is reasonable to assume that the maintenance curve will have an upward trend for an indefinite time. The statement frequently made that eventually all highway expenditures will be for maintenance is at least theoretically true. However, the expenditures for maintenance will never assume the relative proportions that they have for construction.

Why Future Pavement Failures Will Not Be So Extensive.—Pavement failures will not be as frequent nor extensive in the future. This opinion is based on the following facts:

(1) There will be no great or sudden increase in concentrated traffic loads such as occurred when the motor truck came into general use. This is precluded by legal weight restrictions in the statutes of all states and more effective enforcement of traffic laws. In other words, the character of highway traffic so far as wheel loads are concerned has reached a point of stabilization.

(2) Rational design methods and improved construction practices have been developed as a result of past experience and highway research. This applies to both new construction and reconstruction.

(3) Maintenance is more adequately organized and roads receive closer and more constant attention. This will serve to decrease the reconstruction periods.

(4) A more accurate knowledge of traffic existing and projected will be very valuable in future road construction and maintenance. A number of the state highway departments have made or have under way comprehensive transport surveys and indications point to a large expansion in this class of investigation.

In this connection about 40 per cent of the average road improvement consists of items on which the depreciation is practically negligible—the roadbed and drainage structures. It is true that in a few states maintenance expenditures are already equal to expenditures for construction. This is due, not so much to the fact that the main routes of travel are already improved, but because a large mileage of roads was designed and constructed when the traffic was light in volume and weight.

Attitude of Highway Contractors.—An interesting angle is the attitude of the highway contractors themselves toward this question. As would naturally be expected, they are as a rule ardent advocates of maintenance by contract. However, many of them realize that maintenance contract work, from its very nature, constitutes an effective training school for future competitors in the larger field of new construction. From their point of view, the policy may not be an unalloyed benefit.

Looking at the question from a personal—and somewhat narrow—viewpoint, contracting maintenance work will serve to transfer many controversies and burdens from the highway official to the broad shoulders of the contractors. The policy will undoubtedly win increased support, of a substantial and legitimate nature, for a program of adequate maintenance, reconstruction, and widening of existing highways. The possible evil of building up, by those in power, of a large personal political following composed of employes on the public payroll is minimized. In view of the fact that as our highway systems are gradually completed maintenance, in its broadest sense, will become the major operation, performance by contract can well be classified as a forward-looking policy that will be for the ultimate good of the most remarkable development in transportation recorded in history—the motor vehicle and the highway over which it operates.

A Contractors' Tractor That Carries Loads

The Linn Tractor, recently introduced in the road construction field, is more than a tractor and in fact is a heavy duty motor truck with traction gained by a track-laying type of crawler treads in place of the rear wheels. It is said to combine the advantages of tractor and motor truck, with the tractor's ability to handle heavy loads over the worst ground, and the body capacity of a large truck. Since it is the conventional truck with the exception of the tractive device, any average truck driver makes a good operator with but little new instruction. There is nothing about the machine that would make the driver problem, nor the upkeep problem difficult. It is made of standard truck parts except for the traction member. This latter is simple and is said to require no attention except for oiling, and to be practically trouble proof.

The steerage principle involved is said to cause practically no wear on any part of the mechanism, and enables it to travel along a path offset from the path of its tow. It is a one-man machine handled exactly like a truck.

The tractive member is so designed that no load is carried on any axle. The weight of the machine travels over the hubs of large spool rollers, the flanges of which, in turn, travel along the track. Track parts are of 12 per cent manganese steel. The track itself is flexible to afford complete bearing on the ground at all times. A compensating device aids travel over uneven surfaces, and permits ejection of obstructing materials that might otherwise stall the mechanism. The transmission provides four forward speeds, with a maximum of 8 m.p.h. with the 100 h.p. machine.

The Linn tractor is manufactured by The Linn Manufacturing Corporation, of Morris, New York.

Work of Delaware Bridge Department

During the year 1926 the bridge division, Delaware State Highway Department, built 3 bascule bridges and designed 23 fixed highway bridges of spans between 6 ft. and 34 ft., and selected and located 250 culverts. The year's drainage structures, exclusive of the movable spans, entailed an expenditure of $130,000. Of this amount $80,000 was spent on bridges and $50,500 for culverts.

A Linn Tractor Serving a Power Shovel on Excavation

Preventing Scaling on Concrete Pavements

Methods Used in Illinois for Reducing the Amount Described in Concrete Highways and Public Improvements

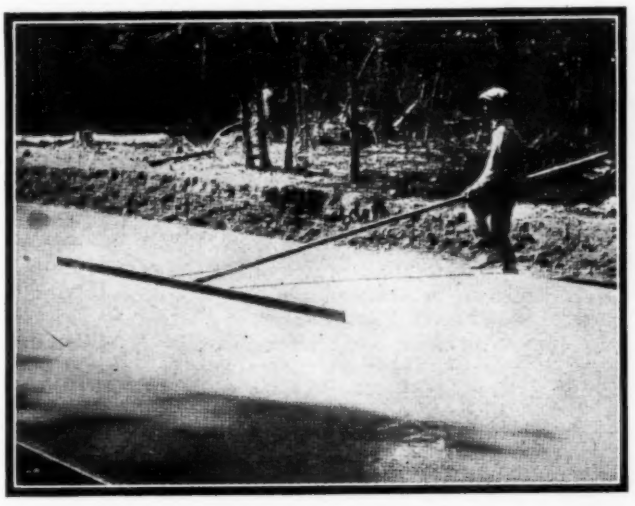
By OSCAR DAY

Assistant Engineer, District No. 9, Illinois Division of Highways

Scaling is not an inherent or natural quality of pavement concrete, but is an occasional condition brought about by a combination of factors, most of which can be eliminated.

The Illinois Division of Highways has eliminated many of these factors—(1) by requiring clean aggregates; (2) by reducing tamping operations to a minimum; (3) by careful and intelligent finishing operations.

Methods of Removing Laitance.—After the compacting or finishing machine has gone over the pavement a minimum number of times, the surface is belted and tested for variation by means of a 10-ft. straightedge. Any "bumps" over ¼ in. are removed by means of long handled floats or straightedges. Then all surplus water, laitance, or inert material is removed by one of the following methods, (a) the entire surface of the pavement is scraped with a straightedge having a length of not less than 8 ft. nor more than 15 ft.



Removing Laitance, Water and Inert Material with Long Handled Straightedge

(1) If less than 10 ft. in length, it is operated from the side of the pavement by means of a long handle.

(2) If more than 10 ft. in length, it is operated from a bridge resting on the side forms.

(3) The scraping or floating is accomplished by drawing the straightedge from the crown of the pavement to each side in such manner that all laitance, surplus water, and inert materials are removed from the surface.

(4) At each operation of the straightedge there is a one-half lap longitudinally.

or:

(b) The entire surface of the pavement is rolled with a smooth roller not less than 6 ft. in length, operated by means of ropes or long handles.

(1) This roller is operated in a transverse direction from one edge of the pavement to the other and back again over the same area.

(2) A one-half lap is then made and the rolling continued until the entire surface is covered.

The scraping method is probably the most practical as well as the most popular. It is easy to visualize how a shorter straightedge than the minimum length of 8 ft. might tend to create a series of minute hills and valleys in the concrete surface and a consequent undulating pavement. A straightedge longer than 15 ft. would be cumbersome and impractical. A straightedge of length somewhere between 8 and 15 ft. accomplishes a two-fold purpose: First, the removal of laitance and finely divided inert material; and second, the removal of small irregularities of less than ¼ in. which would otherwise remain in the pavement.

After the laitance is removed the surface is again checked with a 10 ft. straightedge and any irregularities over ¼ in. removed. Then "when the surface of the concrete is free from water and just before the concrete obtains its initial set" it is given a final belting. Probably no set of specifications is so perfectly devised as to cover every detail arising during construction.

Final Belting and Covering.—The exact time at which the pavement is to be given the final belting and covered with burlap is very important in the prevention of scaling. Other conditions which work to cause a field for scaling are a continuously wet mix or the presence of an occasional wet batch. The occasional wet batch is the hardest item to eliminate. Try as you will to obtain a perfect stock pile there will be one or two batches in 100 ft. in which the coarse aggregate will be just a little coarser than in the remaining batches. As long as we have rain falling on sand in a stock pile there will be one part containing more moisture than another. The pressure on the water line leading into the mixer seems to vary occasionally and any one of these conditions is likely to cause the occasional batch that contains more moisture than the other batches.

Where we have a wet batch, the water will rise to the top at that point after it has ceased to rise elsewhere and this one spot must be given another scraping before the final belting or we have a possible scaled area. Giving the pavement the final belting before all the water has ceased to rise to the top and placing the burlap upon this concrete will cause a field for future scaling. This condition is usually brought about through running a consistently wet concrete.

Causes of Scaling.—There are two conditions which are often neglected that will cause a very thin scale to develop:

First, sprinkling the green pavement on a warm day with cool water will tend to cause a thin scale through the weakening of the top concrete by washing out the cement in combination with the sudden contraction of the top of the pavement due to the change in temperature; and second, placing dry burlap on green pavement on a warm day and sprinkling the burlap, while it is on the pavement, with cool water. The sudden change in temperature of the concrete seems to break loose from the rest of the pavement a thin scale on the top.

The scale that we notice often develops after the first radical change in temperature and frequently in the spring. The thickness of the scale will depend on the amount of inert material left on the pavement during construction and is sometimes ¼ in. in thickness.

During the past two years, in which time the method described above has been used, we have found that good materials inspection and good construction inspection following the Illinois specifications to the letter have produced a pavement practically free from scaling.

California to Oil 700 Miles of Roads.—The state of California plans to oil 700 miles of crushed stone and of gravel roads during the year at an estimated expense of $600,000.

Classification of Excavation Material

An Interesting Discussion By a Well Known Contractor Given In Northwest Associated General Contractors News

By J. C. BAXTER
Vice President, A. Guthrie & Co., Inc., St. Paul, Minn.

I may say at once, there is only one possible classification that will at all times meet the contractor's point of view, and that is "Solid Rock 100 per cent," but such an ideal result is not to be expected and would probably effect the mental ruin of most contractors by removing any opportunity for the mto sharpen their wits in argument with the engineers, I think it may be asked "what does the contractor expect in the classification of excavation materials," and speaking from the contractor's viewpoint, I should expect:

That the engineer preserve at all times a very clear conception of the idea that when passing on classification he is not an agent of the individual, firm, corporation, or political body that pays his salary, but is in reality an arbitrator between the two parties to the contract and must be absolutely fair and unbiased in determining classification.

Causes of Classication Disputes.—I think it will be agreed that most disputes as to classification which reach a stage calling for the intervention of the courts arise from two causes:

(1) Failure on the part of the contractor to realize he has received a fair and unbiased determination of classification.

(2) Failure on the part of the engineer to remember that he must be absolutely fair and unbiased in determining classification.

The first of these causes, that of the contractor failing to realize he has been justly paid, is often due to the accident of an improperly financed firm securing work at too low a figure and when the inevitable crash comes, laying the blame upon the engineer, but I wish to say here, that the implicit faith, confidence, and particularly acquiescence shown by the average contractor and sub-contractor in the final work of the engineer is a glowing tribute to that profession.

The second of the causes, that of the failure of the engineer to be fair and unbiased, will be discussed later.

"What Is Classification?"—I have said the contractor expects the engineer to be fair and unbiased in determining classification and the question immediately arises, "What is classification?" The term classification as used between contractors and engineers, covers the operation of dividing the total quantity of any excavation material into several smaller quantities, each of which carries a separate unit price, these unit prices varying from a comparatively small price for earth or other easily moved material through several gradations to a comparatively high price for solid rock.

This sounds simple and it is when all the material in one excavation is, let us say, sandy loam, or at the other end of the scale, is all hard rock, suitable for good building stone and the problem is still comparatively simple when such easily definable materials as sandy loam or good building stone exist in the same excavation in the form of separate strata, but such conditions are of more or less rare occurrence for the reason that the earth's crust is composed of mixed materials varying by infinitesimal steps from the finest silt through all combinations of glacial drift and the shales and slates to the hardest rock, and it is in the classification of these mixed and indeterminate materials that the greatest differences of opinion arise.

Classification of Indeterminate Materials.—The difficulty of classifying indeterminate materials must have been one of the first causes of discussion between contractors for excavation and their principals during the dawn of civilization, and on account of it, I suppose there has never lived a construction engineer who at some time in his career has not attempted to clarify the subject by writing a new set of specifications for classification and as a result, we have the multitude of various schemes now in more or less general use, such as,

Earth—hard pan—loose rock—solid rock. Earth—loose rock—solid rock. Common—solid rock. Earth—all other material. No. 1—No. 2—No. 3. Soft—medium—hard; and so on without end.

I think it will be agreed that no scheme of classification that has been proposed covers completely and without possibility of dispute, all the variations of material that are likely to be met with in any ordinary excavation, and, that being granted, the thought immediately suggests itself of solving the difficulty by eliminating all classifications save one.

Now, this has been done many times, and as far as my experience goes, always with the same result, namely, the raising of the average price per cubic yard paid by the owner. This fact was well illustrated by a letting of the bureau of public roads for several hundred thousand yards of excavation on the Pacific Coast. This work was let on a one-classification basis, and my information is that the low bid was in the neighborhood of 80 ct., the high bid about $1.20, in a country largely but not entirely composed of soft solid rock, which on a 2, 3, or 4 classification basis would probably not have been bid in at a higher price than that bid for all of the material on a one-classification basis. With the foregoing in mind, I believe we may agree that the best interests of all parties to an excavation contract; the owner, the engineer, and the contractor, are served by a specification that carries two or more classifications.

Having first said that no system of classification now in use covers all of the materials likely to be encountered and then having said that the best interests of all concerned are met by a specification carrying two or more classifications, I have arrived at what appears to be a highly inconsistent position. This inconsistency will disappear, however, when we examine into the probable origin and the proper application of classification.

Origin of Classification.—There is not, as far as my knowledge goes, very much written history of the engineering and contracting professions reaching back into antiquity. We know, however, that great works involving excavation were carried out, and we know that ancient peoples had laws governing contracts between individuals, and individuals and the state, and it is reasonable to suppose that much of the excavation in early times was carried on by contractors who would be supervised by, and paid through, the engineers of that day; that is the mathematicians, who were the only men competent to lay out work and to measure it.

The engineers of antiquity must have soon encountered the necessity of paying the contractors for harder materials and they were then face to face with exactly the same problems that are before us today. These engineers or mathematicians were familiar with plus and minus quantities varying each way from zero as a gage point, and they undoubtedly were also familiar with gage points on rivers where the water rose and fell below some fixed point.

They had created the calendar in which the continuous flow of time throughout the year is divided into months, days, hours, etc., and it is natural to suppose that they should solve the difficulty of paying contractors for harder materials by establishing gage points to govern their payments; the softest and most easily moved materials being paid for at the lowest prices, the hardest at the highest prices, and after this procedure had been adopted, it would soon become convenient in certain areas where large quantities of easily definable intermediate material existed to establish one or more intermediate gage points corresponding to our present "Hardpan" and "Loose rock" classifications.

Application of Classification.—We may assume, I believe, that classifications such as we are discussing originated in about the same manner I have outlined and probably at a very early date, and as a somewhat parallel case, I recall to your memory, the story of Archimedes, who as one of the early

engineers about 250 B. C., was called upon to classify the materials in the crown made for Hiero, King of Syracuse, and determine whether or not the crown which was contracted for to be constructed entirely of gold, did not actually contain a proportion of silver. Had the gold and silver in that crown been separable, any layman could have determined the quantity of each, but they were not, and so it was necessary to call upon an engineer, one skilled in the laws of nature, to make the determination.

It is so with the materials of excavation. Any layman can determine soft, sandy loam as earth, or granite building stone as solid rock, or pieces of granite exactly one cubic foot in volume as loose rock, but it calls for the engineer, bringing with him his training, his experience, and the traditions of his profession from the days of Archimedes, to determine the classification of intermediate materials which are each of them composed of certain proportions of one of the classifications furnished as gage points by the contract under which his determination is to be made, inseparably, mixed with varying proportions of one or all of the other classifications available.

This is my idea of the application of classification. The engineer must, in the light of his training, his experience, the traditions of his profession, and the information obtainable on the work itself, determine for every intermediate material the percentages of the various classifications it contains, and the only available criterion obtainable on the work itself with which to supplement his own knowledge and experience is the relative difficulty or cost of moving the material under consideration.

When the engineer fails to control his determination of intermediate materials by the criterion of relative difficulty or cost of removal, then an injustice is likely to fall upon either the owner or the contractor, and in addition there is grave danger of a dispute arising that must be adjudicated in the civil courts.

As you all know, a large proportion of law suits involving classification are lost by the owners, and I want to say that in my experience, extending over more than twenty years, both as an engineer and a contractor, I have never known the details of a classification law suit that could not have been avoided had the engineer exercised the tremendous powers conferred upon him by the contract, with the complete acquiescence of both parties thereto, and kept in mind the fact that he was not an agent of his employer, but in reality an arbitrator between two parties to a contract, and obligated to be absolutely fair and unbiased in determining classification. A good many years ago I, as an engineer, failed to do these things and a contractor sued my principals, who lost the case.

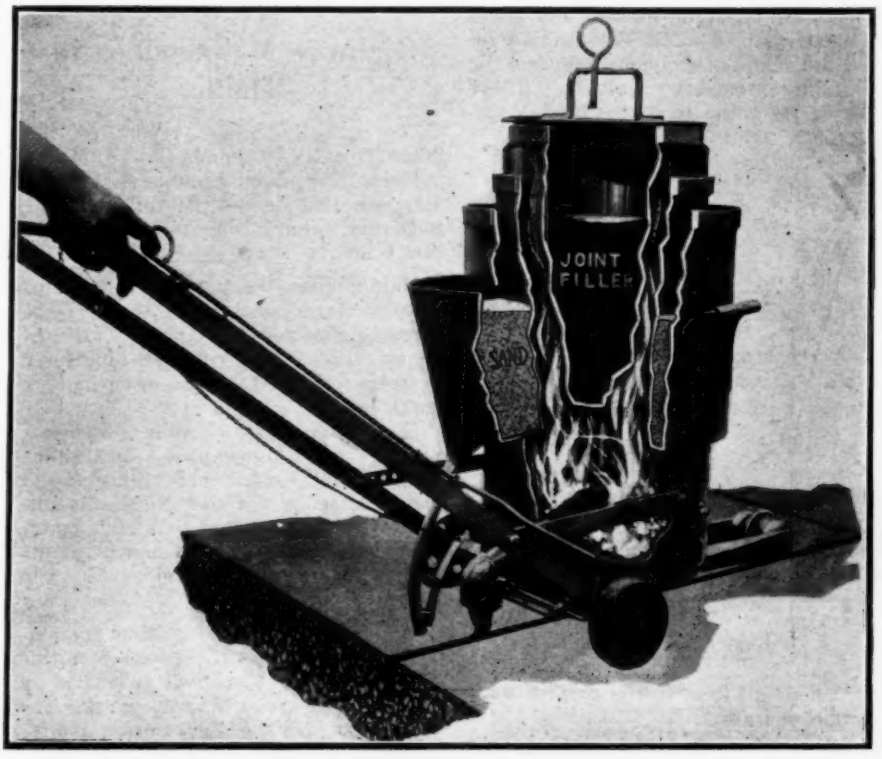
Machine for Pouring Pavement Joints

A new joint pouring machine has recently been developed by the Heltzel Steel Form and Iron Co., of Warren, O., which heats, pours and sands.

The machine is so constructed that the fire is between the joint filler compartment and the sand compartment. The filler discharge pipe passes through the fire box maintaining a uniform heat and causing the discharge nozzle to deposit the filler at a uniform temperature. The flow at the discharge nozzle is regulated by a needle valve.

It is stated that inasmuch as the filler is heated at the time of pouring it penetrates clear to the bottom of the joint. The flow of sand and filler is controlled by hand handles, which are adjustable as to height. No bridging is necessary and the broad tread wheels do not mar the concrete. A pilot wheel running in the joint insures perfect alignment.

The sanding compartment is recommended for use on grades to prevent the filler from flowing out, but is not necessary on semi-level roads. A fire box is provided for any kind of fuel or is equipped with oil burner when desired.



Heltzel Joint Pouring Machine

Houston to Spend Million.—At a recent election the city of Houston, Tex., voted a bond issue of $1,000,000 for street paving and another of $500,000 for the resurfacing of gravel streets, according to a recent news release.

Forced Settlement of Fills

Forced settlement of highway fills to hasten the time when it will be safe to lay pavement on new grade is a subject of extreme interest to every road builder.

The results of numerous tests made by the engineers of the federal and state road commissions have shown that water saturated earth quickly settles, and when dried out attains a solid and permanent level and is practically free from side slips or slides.

Puddling the fill, as it is made, is one method. Boring 6 to 10 in. holes on 5 to 8 ft. centers over the entire fill and keeping these holes full of water for a period of from two weeks to a month also accomplishes the desired results. Another method is to "jet" water under pressure into the earth.

On five foot centers a 1½ in. "jetting" pipe with a ½ in. nozzle, discharging water at about 60 lb. pressure at nozzle, is used to penetrate the earth at about a 30 degree angle. The pressure of the water is stated to not only quickly saturate the soil but forces the loose earth into the voids and produces quick and permanent settlement.

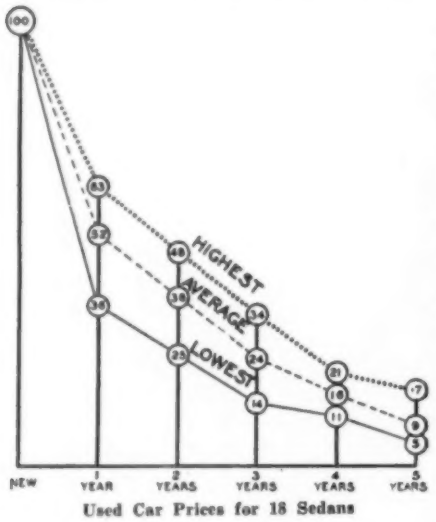
Costs of State Police

The State Highway Police Force, operated by the state of Delaware, cost, from Jan. 1 to Dec. 1, 1926, a total of $80,123.06. Fines received after arrests by the force during that period totaled $37,577.00. Thus it can be said that each patrolman cost the state $117.17 per month.

Used Car Prices

When an automobile is new the largest item of cost in operating it is that of depreciation. Repairs are few and inexpensive. When the car is three or four years old the item of depreciation becomes a minor one in its contribution to the cost per mile of operation, but repairs are frequent and expensive. Some interesting information on this matter of car depreciation is given in the April 15 Business Bulletin of the Cleveland Trust Co., from which we quote as follows:

The market values of second-hand cars are now becoming relatively well standardized. They are closely estimated from month to month from the records of actual sales of large numbers of cars of different makes, and trade publications of established standing report to dealers at frequent intervals the prevailing market values. These records show the importance of depreciation as an item in the cost of automobile operation.



Used Car Prices for 18 Sedans

The diagram is based on data from one of the recent trade reports on the going prices of used cars. The quoted prices of the sedan models of 18 different makes were used. The figures show that if the price of each car when new is taken as equal to 100 per cent, the one showing the least depreciation after one year of use had then a market value of 63 per cent of its original price. The average car has a value at the end of the first year of use of only 52 per cent of its first cost, and the car showing the most rapid depreciation among these 18 makes has a market after one year of use of only 36 per cent of its cost when new.

The corresponding figures for the second, third, fourth, and fifth years are shown in the small circles of the diagram. They show that the typical closed model of passenger automobile loses about one-half its selling value in its first year of use, almost two-thirds in the first two years, and over three-fourths in the first three years. The depreciation of the most durable cars is so much slower than that of the least durable, that after several years of use they are worth two or three times as much as their more fragile competitors.

The market value of a car that is five years old is discouragingly small. The best record among these 18 makes is 17 per cent, and the poorest one only five per cent of the first cost. The average is nine per cent. Of the two cars making the best records for relatively slow depreciation, one is an expensive 8-cylinder vehicle, and the other an inexpensive four. There does not seem to exist any close relationship between the first cost and relative rate of depreciation.

Highway Maintenance in Maine

The recently issued report of the State Highway Commission of Maine covering the period January 1, 1924 to June 30, 1926, gives the following information on highway maintenance in that state:

Maintenance Work for 1924.—Maintenance work during 1924 was performed generally by patrol maintenance. Four hundred and ninety-six patrolmen were employed in caring for 4,481.74 miles of road in 483 towns. Of this mileage 1,040.77 miles was improved state highway, 1,375.04 miles was improved state aid highway and the balance or 2,065.93 miles was unimproved road. There was also maintained by special arrangement with the towns 294.04 miles of improved state aid road.

A total expenditure for labor and material of $1,447,034.31 was made on this work, including $20,525.81 furnished by the state for road machine work. The state also furnished supervision and inspection for the work amounting to $46,561.60, making the total gross expenditure chargeable to maintenance of $1,493,595.91. Of this amount the state furnished $1,248,297.82 and the cities and towns furnished $245,298.09. The average expenditure per mile was $333.26.

On the 1,040.77 miles of improved state highway, the expenditure for labor and material and supervision was $927,872.84 for an average expenditure per mile of $891.53. The expenditure on the 3,440.97 miles of other road under patrol was for labor, material and supervision $552,393.83, or an average expenditure per mile of $160.53.

Maintenance Work for 1925.—Maintenance work during 1925 was performed generally by patrol maintenance. 494 patrolmen were employed in caring for 4,582.46 miles of road in 486 towns. Of this mileage 1,152.20 miles was improved state highway, 1,495.83 miles was improved state aid highway and the balance or 1,934.43 miles was unimproved road. There was also maintained by special arrangement with the towns 292.51 miles of improved state aid road.

A total expenditure for labor and material of $1,652,241.73 was made on this work, including $20,818.31 furnished by the state for road machine work. The state also furnished supervision and inspection for the work amounting to $32,712.65 making the total gross expenditure chargeable to maintenance of $1,684,954.38. Of this amount the state furnished $1,435,598.91 and the cities and towns furnished $249,355.47. The average expenditure per mile was $367.69.

On the 1,152.20 miles of improved state highway, the expenditure for labor and material and supervision was $1,094,927.27 or an average expenditure per mile of $950.21. The expenditure on the 3,430.26 miles of other road under patrol was for labor, material and supervision $574,128.53 or an average expenditure per mile of $167.37.

2½-in. Paving Brick Added to Official List

Taking cognizance of an increase in shipments of 2½-in. paving brick from 31,802,533 in 1925 to 58,468,007 in 1926, the "Permanent Committee on Simplification of Variety and Standards for Vitrified Paving Brick of the Department of Commerce of the United States," at its meeting in Washington March 31 reinstated this size in the list of recognized types and sizes of paving brick.

The revised list of recognized types and sizes of vitrified paving brick as determined by the committee and the percentage of total shipments represented by each size is as follows:

	Per Cent
Plain Wire-Cut Brick	
2½ in. x 4 in. x 8½ in.	14.1
3 in. x 4 in. x 8½ in.	38.2
3½ in. x 4 in. x 8½ in.	5.9
Repressed Lug Brick	
4 in. x 3½ in. x 8½ in.	14.5
Wire-Cut Lug Brick	
4 in. x 3½ in. x 8½ in.	6.4
	79.1

The remainder of 20.9 per cent was made up of special sizes or types not included in recognized list.

The survey of the industry, made by the U. S. Department of Commerce to serve as a basis on which the simplification committee annually makes its decisions, revealed an increase in total shipments of paving brick for 1926 over 1925.

Total shipments for 1925 were 353,588,777. Those for 1926 were 413,125,469, or a gain of 59,536,692 for last year.

The 2½-in. brick was the only size showing a notable gain in percentage of total shipments, representing 8.9 per cent in 1925 and 14.1 per cent in 1926.

Santa Maria Bridge

Construction Features of 1,368 Feet Reinforced Concrete Pile Trestle on Coast Highway, California

A number of interesting features were involved in the construction of the recently completed 1,368-ft. reinforced concrete pile trestle bridge over the Santa Maria River, on the Coast Highway, 2 miles north of Santa Maria, Calif. The structure, which replaces a wooden pile trestle, consists of 36 38-ft. 4-girder reinforced concrete spans, with a 24-ft. roadway, on reinforced pile bents, with 6 piles to the bent.

Flood Conditions. — The Santa Maria River, with tributaries, drains a mountainous, unforested catchment area of approximately 2,500 square miles. The flow varies from no water at all in dry seasons to 100,000 second-feet after heavy storms, when rises are rapid and destruction often is serious in the sandy lowlands in which the bridge is situated. The present ¼-mile channel is in a new and apparently permanent course of the stream. The old channel, now flooded only at extreme overflow, is about 2,000 ft. south.

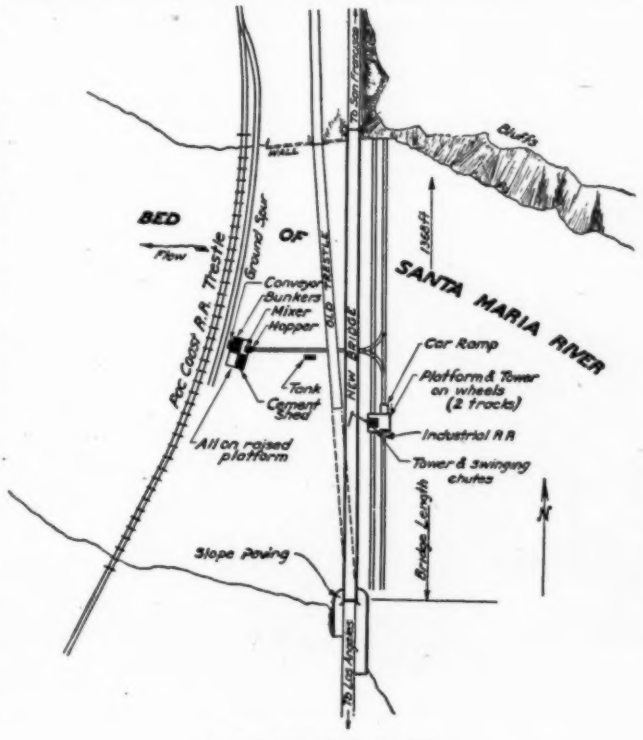
When a location was determined upon for the new trestle, the sites of the southern ends of the old and new bridges coincided, but the center lines diverged toward the north. Accordingly, to facilitate handling of traffic while construction was under way, a schedule of operations was prescribed in the contract.

The southerly 500 ft. of old trestle, encroaching upon the site for the new bridge, was first removed and replaced by a plank road in a new location, which was connected to the northerly portion of the trestle by a ramp. The southerly 500 ft. of new bridge was then constructed. Following the November rains, the river washed out the plank road and a short section of bridging was angled across so that traffic could use the completed portion of the new structure.

How the Construction Was Handled. —The length of the trestle also presented a problem in plant layout which was met by the contractor in ingenious manner, as shown by the accompanying diagram.

A spur was run from the Pacific Coast R. R. to the center of the river bed, which brought the concrete and other materials direct to the storage and mixing plant. Tall aggregate bunkers were filled from the cars by endless chain bucket conveyors. Aggregates were discharged from the bunker by chutes directly into measuring buggies located on a high mixing platform. The cement, brought in on flat cars, was stored in an elevated shed along side the track by means of a small car operated by cable and hoist engine.

A 2-bag, open-tilting Jaeger mixer discharged batches into a reservoir hopper supplying a 1-3-yd. dump car operating on narrow-gauge tracks. The "locomotive" was a "home-made" contrivance resembling a railway "scooter." An inventive combination of Ford transmission for forward speeds, and a Chevrolet transmission for backward speeds, gave efficient and flexible operation.



Contractor's Plant Layout

The narrow-gauge delivery ran to the center of the bridge, split, and paralleled the line of the structure on the upstream side. (See diagram.)

On the upstream side of the bridge a movable hoisting and chuting tower was built on a platform, which in turn was mounted on wheels and two separate tracks, one of which was the delivery line track. An inclined ramp track allowed the locomotive to push the car of concrete mix up to the hoist platform, where the contents were dumped sideways into a vertical skip in the tower. A gasoline engine, with cable and drum, raised the skip which automatically dumped into reservoir hopper above the chute. The flow from the reservoir was governed with a line-operated trip by the hoist engineer. A swinging boom allowed great flexibility in the operation of the two-piece chute which deposited the concrete at the spot desired.

Surface Treated Concrete Piles.—The concrete piles were surface treated to counteract the effect of alkali. All piles, except certain test and experimental piles, were given several coats of water gas tar paint, brush-applied. One coat was applied for full length before driving, and, later, four additional coats were applied on all surface above the ground line and for 2 ft. below the surface.

The test piles, for depth, were of lumnite cement concrete. Certain other piles designated for future investigation by the Testing and Research Laboratory of the California State Highway Commission were cast with (1) Class "A" (6-sack per yd. concrete), (2) with "Laykold" Class "E" asphalt admixture, and (3), with "Biber" admixture. The remainder of the piles were cast with Class "F" (7 sacks per yd.) concrete.

The contract also included grading and paving of the two approaches and constructing a concrete slope paving system on the south fill.

The trestle cost approximately $120,000. It was constructed under the supervision of the Bridge Department of the California State Highway Commission, J. C. Wilson and H. E. Fearnall being the resident engineers. Rocca & Coletti, San Rafael, Calif., were the contractors.

Status of Road Work in Delaware

During 1926 the Delaware State Highway Department let 38 contracts, 35 of which were on road contracts totaling 91.95 miles, and 3 were on bridges. The total estimated cost of the work was $2,429,233.56. Of this amount, $1,959,909.04 was spent on road construction.

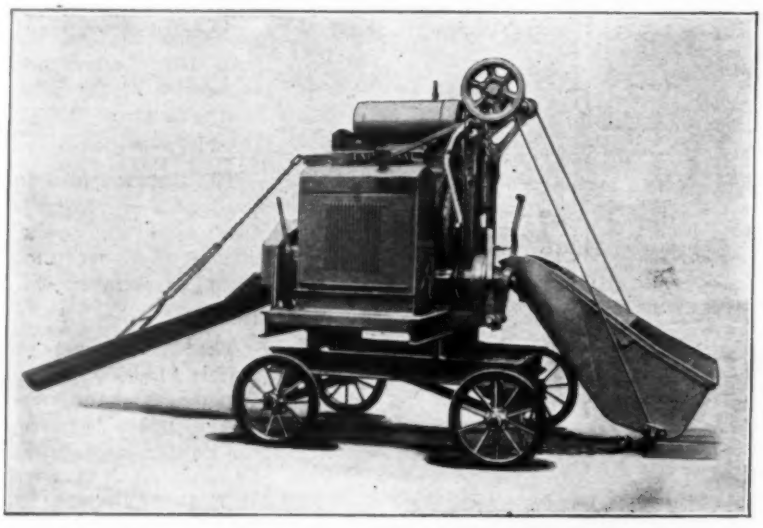
Types of roads for which contracts were awarded include 46.64 miles of concrete, 10.97 miles of sand asphalt, 0.8 mile of amiesite resurfacing, 22.87 miles of slag-clay secondary roads, and 10.67 miles of concrete widening to existing pavements. Work carried over from 1925 totaled 19.15 miles, while work carried over into 1927 totaled 16.5 miles. Work already completed and under way provides for 16½ per cent of the total road mileage of the state, or 592 miles.

New Convertible Mixer for Small Jobs

A new mixer designed especially for small paving jobs, curb or curb and gutter work or for large floors which may be laid in slabs or for sidewalk work is a new development of the Marsh-Capron Co., of Chicago.

The new machine is available in two sizes, one stated to have a capacity of from 30 to 90 yd. per 8-hour day and the other of from 60 to 125 yd. per day. The general design of the machine resembles a miniature paver, being equipped with a standard power loading skip and with a swing spout and distributing chute which can work through an arc of 180 degrees.

In addition the mixer is so mounted on a frame that in a few minutes time it can be changed from an end discharge to side discharge by swinging the mixer on the under-carriage. This enables the machine to be used on alley work and such jobs where end discharge is necessary and in a short time to be converted into a side discharge machine for use as a standard mixer on building jobs. The design, therefore, permits the change from paving mixer into a building mixer at will and thus serves as two-purpose equipment.



The New Convertible Mixer Recently Introduced by Marsh-Capron

The power driven skip and skip hoisting mechanism as well as the drum and mixing method are of standard Marsh-Capron design. The distributing chute is supported by swivel pivot and steel head from directly under the discharge through a 180 degree arc. It is supported also with a chain and bridle and chute so that it swings easily and is supplied in either 8 or 12 ft. lengths. On the 12 ft. lengths the outer 4 ft. are hinged to turn up.

The chute has a semi-circular section and in the 8 ft. length operates at a slope of 1 in 2½ and on the 12 ft. length a slope of 1 in 3½. The slope is easily adjustable by changing the length of the chain. The edges of both the chute and bowl are strongly reinforced angles and the receiving bowl is 30 in. long by 22 in. wide.

On alley work the large machine is said to have a capacity for laying 160 lin. ft. on standard 16 ft. alleys 6 in. thick. The small machine can accomplish about half this much work in a day, according to the manufacturers. Both the above figures are based on a 1 : 2 : 4 mix. On straight curb work the capacity of the large machine using a 1 : 2 : 4 mix is said to be about 800 lin. ft. per 8-hour day while the smaller size does half this amount. On curb and gutter work the machines will do about half the number of lineal feet of straight curb.

According to available literature, the new machine has proven valuable in laying large floors such as garages, etc., where it can be started at the end furthest from the street and the floor laid in a continuous slab, thus reducing the average haul of the material to half the distance from the curb.

Ruling Against Farmers' Tractors Favors Ohio Roads

Attorney-General Edward C. Turner of Ohio, in a ruling handed down a few weeks ago, said that farmers who persist in driving tractors whose wheels are equipped with irons that cut into the road should be sued for damages by county prosecutors. Injunction proceedings as a remedy were also suggested. A further remedy, according to the ruling, would involve prosecution for misdemeanor, carrying a fine of $10 to $100.

The ruling states that a flat strip of wood or iron fastened to the wheels or tires of tractors, to keep them from slipping, may be construed as a "cleat" and be permissible under the current law, but that an angle iron violates the statute.

Hex-Top Grease Cups Furnished With Alemite Fittings

The Link-Belt Company, of Chicago, Indianapolis, and Philadelphia, has announced a new "Hex-Top" malleable iron compression grease cup with alemite, or zerk fittings, for installation on any type of equipment.

The trade name "Hex-Top" describes the shape of the grease cup head. Six-sided, it offers, for turning, an easy purchase for any type of wrench, and a good grip for the hand. The combination of compression grease cup and alemite fitting is an improvement over either article used separately, since it makes available the advantages of both.

An example of this would be in the lubricating system of a long belt conveyor using many grease cups for the idlers; here the easiest, quickest, and most economical way to fill all the cups at one time, it is said, is with a grease gun applied to the alemite fitting, when the cap is turned up to a high point, but not entirely unscrewed or removed. The filling can be done without waste of grease, and without any inconvenience; the cup holds a good reserve for use of the compression feature, and an occasional slight screwing down by hand or wrench is all that is necessary until it is time to have a general refilling of the cups. If a bearing gets warm when the grease gun is not at hand, a turn or so of the cap takes care of the emergency. The cup may be readily filled in even the most inaccessible places.

These grease cups are reported to be now available, supplied as before-mentioned, with various types of alemite fittings.

River Guages for New Highway Bridges

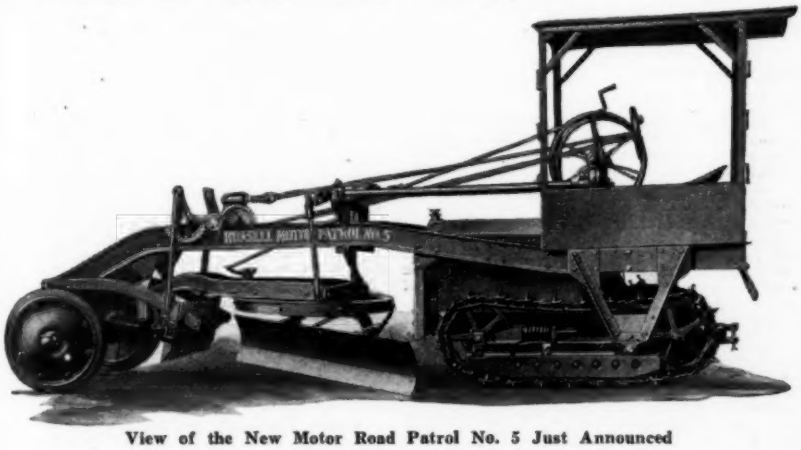
New highway bridges are constantly being constructed in every part of the country. Both as a matter of record and of public convenience, every bridge should have a river gauge on some part of its structure, says the weather bureau of the United States Department of Agriculture. The installation of river gauges of a more or less permanent type can best be accomplished while the bridge is under construction. It is to be expected that officials in charge of river districts, as well as other stations having river work, will report to the central office of the weather bureau when new bridges are contemplated, but it is also suggested that individuals observing such plans, or engineers or contractors in charge of them, might communicate with the nearest weather bureau station with regard to the installation of a river gauge. Arrangements can then be made with the proper authorities for cooperation in installing river gauges, if desired, of a permanent character and at the same time in keeping with the general architectural effect.

Russell Announces New Motor Patrol

The Russell Motor Patrol No. 5, is the latest of road maintenance machines made by the Russell Grader Mfg. Co., of Minneapolis. Like their other motorized patrols, it is the practical adaptation of the Russell model—blade and scarifier mechanism—this time to the Cletrac tractor.

With the "Cletrac K-20" tractor for power, this new unit is built for light and quick as also for heavy and slower work and designed to insure economy, better execution, better service and lower up-keep cost.

The standard length of blade with the No. 5 is 10 ft. However, other lengths are furnished. The back of the blade is reinforced by two heavy angle-irons, which support the blade. The circle supporting the blade is 52 in. in diameter, affording wide and rigid support. A clamping device on the circle locks it and prevents all play. A snug fitting and dependable lock are added features.



View of the New Motor Road Patrol No. 5 Just Announced

The blade is raised and lowered by an easy-running, cut worm-gear, which is enclosed in a machined housing, keeping it free from dust. Bronze bushings and collars are on the worm shaft, showing that no expense is spared to produce a perfect machine. Other features are: shafts of the lifting arms of high carbon steel, keyed to both gear and lifting arms; take-ups for wear, in worm brackets and forward left-arm brackets; ball and socket connections for lifting links.

The center shift allows shifting the blade to either side of the frame; it is rack-and-pinion type, operated by worm and gear. The front wheels are 32x5 in. rubber tired, with Timken bearings and a spread of 53 in.

The one-man operator's station at the rear of the tractor gives full view and ease of quick adjustment.

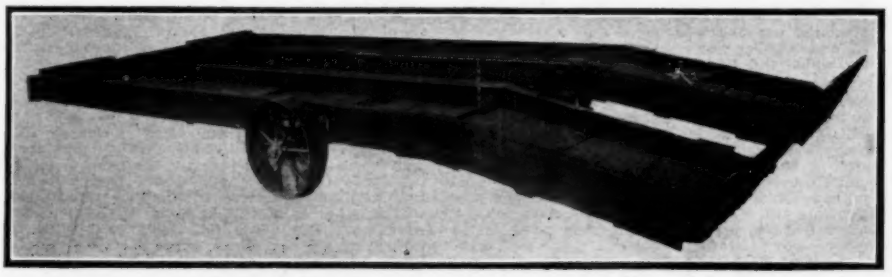
The scarifier is independently adjustable from the rear platform, working with blade, or independent of blade, as desired.

Snow Fence Proves Effective In the East

A snow fence that is said to have proven quite effective on state highways in New York, Massachusetts, Maryland, Pennsylvania and in several other eastern states is manufactured by the New Jersey Fence Co., of Burlington, N. J. Like other snow fences, it is intended for use at points where snow normally drifts on the road, and functions by intercepting the drift and causing it to form at a point well away from the highway. This fence is a combination of white cedar pickets, interwoven with No. 12 gauge galvanized steel wire in double strands, with four twists between each picket. The pickets are 2 in. wide and about ½ in. thick, and are said to be made of the best grade lumber. The fence is made by machine, with tie wires drawn tight so as to hold every picket firmly. Gothic, or square ends, stained or unstained, furnished as desired. The fence comes in rolls of 100 ft., and can be dismantled each spring with ease.

Putting Wheels on Turntables for Portability

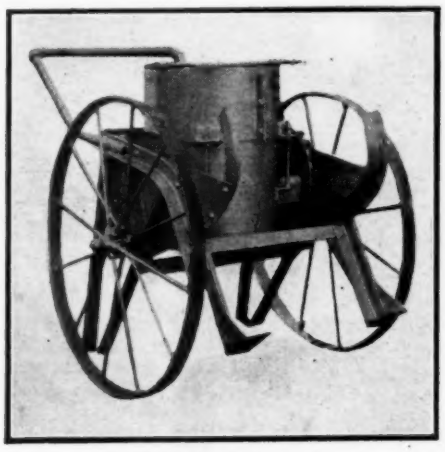
Provision has been made for the attachment of wheels on Blaw-Knox turntables to solve the problem of portability. It is a simple job to attach these wheels for moving the turntable along soft sub-grade or for transportation from job to job. These wheels can be attached in a few moments by jacking up the turntable a few inches and slipping on the wheels.



Blaw-Knox 5-Ton Truck Turntable Mounted on Wheels

Inundator for the Small Wheelbarrow Job

The junior inundator has been developed by the Blaw-Knox Co., Pittsburgh, Pa., to measure sand and water to automatically accommodate for the variable moisture in the sand and at the same time automatically eliminate a further variable by compensating for the bulking of moist sand. The inundator requires no change in the rest of the equipment on the job.



Blaw-Knox Junior Inundator

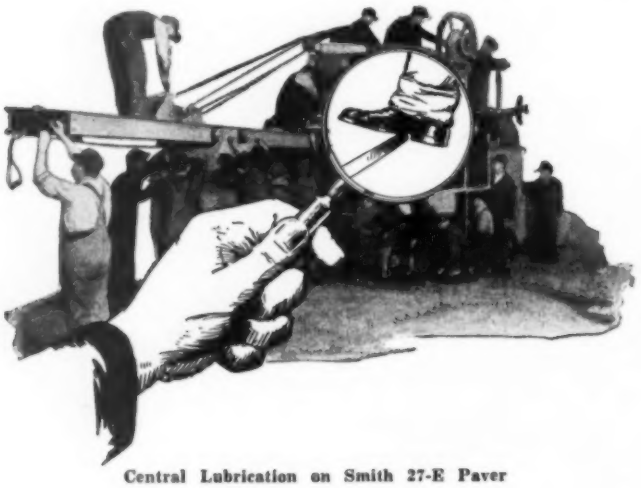
Contractors' Association Establishes Safety Fund

Accident prevention in the construction industry should make great advances within the near future as the result of establishment of a fund to be used by the Associated General Contractors of America in the campaign against mishaps which that organization is carrying on.

The fund was created by the W. E. Wood Company, Detroit, W. F. Austin, president of that company, made the announcement at the Asheville meeting of the Associated General Contractors that his firm would give $5,000 to establish an accident prevention fund in memory of W. E. Wood. Soon after, the Detroit Chapter of the Associated General Contractors subscribed $5,000 to the fund.

Centralized Lubrication for Paver

Central lubrication from the operator's platform has recently been installed as standard equipment on the Smith 27-E six-bag paver, which is stated to enable the operator, by simply pressing a lever with his toe, to force lubrication simultaneously to the bearing surfaces in the machine. One man is stated to be now able to do the work of 30 in a fraction of the time, and the ease with which this central system is operated not only insures perfect and consistent lubrication, but encourages frequent attention on the part of the operator.



Central Lubrication on Smith 27-E Paver

New Trade Publications

The following trade publications of interest to highway officials, engineers and contractors have been issued recently. Copies of them can be obtained by addressing the firms mentioned:

Road Machinery.—The line of road builders' equipment manufactured by the Galion Iron Works and Manufacturing Co., of Galion, O., which includes rollers, graders, gravel spreaders, plows, back fillers, road drags, force feed oscillators, belt conveyors, catch basin covers, scrapers, sprinkling wagons, crushers and gravel screening plants, has been displayed in a folder commemorating the growth of the organization during the past 20 years. Another folder, received at the same time, describes in more detail the Galion Little Master roller that has planer and scarifier attachments, and that is powered with a Fordson tractor.

Resurfacing.—The Barrett Co., in a reprint entitled "Revolutionizing Methods of Salvaging Old Highways," tells of how Tarvia resurfaces worn out roads and makes them serviceable at a moderate cost.

Tractors.—The "Model D" Circular issued by the Trackson Co., 500 Clinton St., Milwaukee, Wis., describes in detail the new heavy duty model Trackson Full-Crawler, which is now in production. One page is devoted to the construction and mechanical features of the new machine, showing side, front and rear views of it, and another page describes the various uses for which the Model D is designed.

Excavating Machinery.—The General Excavator Co., Marion, O., has sent us an interesting bulletin, No. 2703, describing general excavators. This excavator, which may be rigged for power shovel, crane, dragline, ditcher, trencher, skimmer, or backfiller work, is a general utility machine equipped with crawler treads and powered with a Buda 45-h. p. engine, or electric motor. Controls are arranged for one-man operation and other features are of the type demanded by the present-day operator.

Traffic Signals.—The Interflash Signal Corporation, 120 Broadway, New York City, is about to distribute an interesting circular describing and charting the application of their interflash 4-way and 8-way signal heads to various types of street and highway intersections. Six general types of intersections are shown and the light installation needed for their protection indicated. The interflash signal is of the type widely used by the U. S. Lighthouse Service for airway beacons, for landing field beacons and for other similar services, and burns acetylene gas supplied by the Prest-O-Lite system.

Finishing Machines.—A. W. French & Co., 8440 Lowe Ave., Chicago, Ill., manufacturers of the Ord Concrete Road Finisher, has just begun the distribution of the first of a new series of folders describing the advantages claimed for their machine. The one on hand illustrates the screeding action that is claimed to give a dense slab of good smoothness, and sets up the claim that the machine eliminates air voids in the slab. A progress of 125 ft. per hour is claimed in this circular.

Tractors.—The Monarch Tractors Corporation, of Springfield, Ill., in a new specification circular, just received, tells about the new size 6-ton Monarch Tractor, Model H, that has been developed. Complete specifications are included in the circular.

Traffic Signals.—The General Electric Co., of Schenectady, N. Y., in their new bulletin GEA-566, describe the Novalux Traffic Signals supplied by them. This booklet not only illustrates and describes the various types of lights available and the automatic synchronous control systems to be included in their installation, but it illustrates the application of the various systems in the solution of a variety of typical traffic problems.

Graders.—The J. D. Adams & Co., of Indianapolis, has issued a new catalogue, "Modern Road Building with Adams' Adjustable Leaning Wheel Graders." An interesting feature is a historical sketch of the 42 years' growth of the company, founded in 1885 by J. D. Adams. This is followed by a discussion, helpfully illustrated by photographs and diagram, of the principles of modern road construction. The catalogue is a presentation of the entire line of Adams graders. Sections are devoted to the Adams One-Man Road Maintainer, the recently acquired Stroud Elevating Graders and Dump Wagons and entire Adams line of attachments and maintenance equipment.

Industrial Notes

The Belknap Hardware & Manufacturing Co., Louisville, Ky., will handle the sales of Climax engines in Kentucky, Northern Tennessee, West Virginia and portions of Virginia and North Carolina. Woodward-Wight & Co., New Orleans, La., are dealers in Climax engines for Southern Louisiana and Southern Mississippi. These appointments were recently announced by the manufacturers of Climax power units, the Climax Engineering Co., Clinton, Ia.

The Geo. D. Whitcomb Co., Rochelle, Ill., manufacturers of Whitcomb gasoline and electric locomotives, announce the appointment of the Clyde Co., 309 Magazine St., New Orleans, La., as representatives for Louisiana and the southern halves of the states of Mississippi and Alabama. The Clyde Co., long established in this field, are the direct representatives of the Clyde Iron Works, of Duluth, Minn.

The Ruggles Motor Truck Co., of Saginaw, Mich., announces the appointment of H. Randall Wickes as general manager, succeeding R. J. Goldie, who resigned. Mr. Wickes has been vice-president of the company for some time and is also vice-president and general manager of Wickes Brothers and the Wickes Boiler Works.

The Geo. D. Whitcomb Co., Rochelle, Ill., has signed a contract with the American Machinery & Supply Co., 1113-1117 Howard St., Omaha, Nebr. This firm, handling industrial plant equipment, contractors' supplies, etc., will cover the entire state of Nebraska and Western Iowa.

Harnischfeger Corporation, of Milwaukee, announces the opening of a Baltimore office at 1402 Lexington Building, under the management of Daniel J. Murphy, formerly manager at Dallas, Tex. The corporation builds electric traveling cranes; also gasoline diesel, and electric-driven shovels, draglines and trenching machinery.

The Massillon Power Shovel Co., Massillon, O., announces the purchase of the power shovel division of the Russell & Co. and the plant and business of the Massillon Foundry & Machine Co., both of Massillon, O. The company has in production the Massillon full revolving shovels, cranes, clam shells and draglines, equipped with steam, internal combustion engines, or electric motive power.

The Geo. D. Whitcomb Co., Rochelle, Ill., wish to announce the return of A. R. Amos on April 10, 1927, to the New York office, working directly under W. A. Smethurst. Mr. Amos, who was formerly attached to the New York office and was located at Philadelphia, and who left the employ early in 1926, is now permanently located at 1014 Harrison Bldg., Philadelphia, Pa.

The Marsh-Capron Co., of Chicago, announce the appointment of four new dealers in the Midwest, three on the Pacific Coast and one in the East. This firm's policy is to select dealers intimately familiar with contractors' problems. Arrangements have been completed whereby dealers will carry repair parts in stock and will be equipped to carry out complete service on the Marsh-Capron products. In addition, the majority of the dealers are to carry new machines on display in their store rooms and will stand ready to make immediate deliveries for contractors in urgent need of equipment. The following new dealers, in addition to a stock of repair parts, will carry complete new machines on display ready for immediate delivery: National Machinery & Equipment Co., 91 Connecticut St., Seattle, Wash.; Marble, Cement & Coal Co., Southern Ave. and Penn. R. R., Muskegon, Mich.; S. M. Caldwell, 406 Mead Bldg., Rockford, Ill.; A. W. Sikking & Co., 116 North 6th St., Springfield, Ill.; R. S. Smillie, Wells Fargo Bldg., San Francisco, Calif., and Burke Machinery Co., Porter Bldg., Portland, Ore. The following will carry a stock of repair parts: Ben Nieboer, 1011 Sherman St., Grand Rapids, Mich., and Bashford-McCord Corp., 1346 University Ave., Rochester, N. Y.

Chain Belt Company officials, at the annual stockholders' meeting recently held, reported 1926 as one of the best years in the history of the company. Sales exceeded 1925, which was the previous high mark, by approximately 10 per cent. The year also witnessed the most extensive expansion program ever undertaken in any one year, and included the purchase of the Stearns Conveyor Co., of Cleveland, and the erection of a new engineering plant at the West Milwaukee Works. Acquisition of the Stearns Conveyor Co. and the new plant approximately doubled the manufacturing capacity for conveyors, elevators, traveling water screens and other engineering work. Since the first of the year two additional branch offices have been established at Birmingham, Ala., and Salt Lake City, Utah. The directors elected for the ensuing year are: Donald Fraser, Wm. C. Frye, J. C. Merwin, Clifford F. Messinger, H. O. Seymour, and Edgar L. Wood. At the directors meeting, held after the stockholders meeting, the following officers were re-elected: C. R. Messinger, president; Clifford F. Messinger, first vice-president; J. C. Merwin, second vice-president; Brinton Welser, secretary; W. H. Brandt, assistant secretary; C. L. Pfeifer, treasurer; F. M. Lowum, assistant treasurer. The Chain Belt Co. is one of a group of affiliated concerns including Federal Malleable Co., Interstate Drop Forge Co. and Sivyer Steel Castings Co. of Milwaukee, the Nugent Steel Casting Co. of Chicago, Ill., and the Stearns Conveyor Co. of Cleveland, O. The company manufactures elevating and conveying machinery, chain for power transmission purposes, and concrete mixers and pavers, all of which are marketed under the trade name Rex.

H. R. Albion has been appointed district engineer in charge of the Jacksonville office of the Portland Cement Association. Before entering association employ in 1926 as a field representative in Florida, Mr. Albion had wide experience in engineering practice, including five years as senior partner of the engineering firm of Albion & Ewing.